1720A

Instrument Controller

Service Manual

FLUKE®

NOTE

This manual documents the Model 1720A and its assemblies at the revision levels shown in Section 4A. If your instrument contains assemblies with different revision letters, it will be necessary for you to either update or backdate this manual. Refer to the supplemental change/errata sheet for newer assemblies, or to the backdating sheet in Section 4A for older assemblies.

1720A
Instrument Controller

Service Manual

P/N 518662
July 1980

FLUKE®

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument controller it manufactures to be free from defects in material and workmanship under normal use and service for the period of 90 days from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, floppy disks or contents thereof, or any product or parts which have been subject to misuse, neglect, accident or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc. will repair an instrument controller returned to an authorized Service Facility within 90 days of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument controller returned within 90 days of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or the nearest Service Facility, giving full details of the difficulty, and include the Model number, type number, and the serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument controller transportation prepaid. Repairs will be made at the Service Facility and the instrument controller returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC., instrument controllers should be made via United Parcel Service or "Best Way" prepaid. The instrument controller should be shipped in the original packing carton. If this original carton is not available a suitable container that is rigid and of adequate size may be used. However, the JOHN FLUKE MFG. CO., INC., does not recommend shipment of instrument controllers in substitute containers. In the event a substitute container must be used, the instrument controller should be wrapped in paper and surrounded with at least four inches of excelsior or other similar shock absorbing material. JOHN FLUKE MFG. CO., INC., shall assume NO risk for intransit shipment damage.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument controller should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument controller is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC. will be happy to answer all application or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX 43210, MOUNTLAKE TERRACE, WASHINGTON 98043, ATTEN: Sales Dept. For European Customers: Fluke (Nederland) B.V., Zevenheuvelenweg 53, Tilburg, The Netherlands.*

*For European customers, Air Freight prepaid.

1720A SERVICE POLICY

WARRANTY POLICY

a. The 1720A Controller is serviced primarily through a module exchange program or by returning the unit to your local service center for repair. Diagnostic software routines have been provided that will allow the user to isolate a fault to the module level. In the event of a failure contact your local service center to arrange for a replacement module.

There is a complete support inventory at each service facility with a 24-hour turnaround time goal on exchange modules.

b. Upon request, on-site service is available for which a "transport zone fee" is charged. The rates for these charges are available from the local office of John Fluke Mfg. Co., Inc.

c. An on-site service contract may be purchased within the warranty period to assure minimum down time.

OUT-OF-WARRANTY SERVICE

a. The 1720A Controller is serviced primarily through a module exchange program or by returning the unit to your local service center for repair. Diagnostic software routines have been provided that will allow the user to isolate a fault to the module level. In the event of a failure contact your local service center to arrange for a replacement module. Module exchange will be available to the customer on a flat rate exchange basis. There will be a complete support inventory at each service facility with a 24-hour turnaround goal on exchanges.

b. On-site service is available on a time and materials basis. Additionally a transport zone fee is also chargeable.

c. An on-site service contract may be purchased to assure minimum down time. Contract support will also assure maximum priority on all service requests. Contracts initiated prior to the expiration of the warranty will not require a reinspection fee.

d. Units may be returned to any service facility for repair with quotations to the customers for estimated time and material charges.

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1720A Instrument Controller

Section 1
Introduction and Specifications

1-1. DESCRIPTION OF THE 1720A DOCUMENTATION

1-2. Several documents are available to serve the needs of a variety of users. Figure 1-1 illustrates the manual set. To obtain additional copies of these manuals, or others when developed, check with a Fluke Sales Office, listed at the end of this manual.

1-3. 1720A User Manual

1-4. The User Manual is an introductory manual for the programmer or system designer who is using the 1720A to set up an instrumentation system. It presents both the purpose of and the interaction between the various software and hardware resources in the 1720A. In addition, it serves as a reference guide for the Console Monitor, the File Utility Program, and the other utility programs. Order Fluke Part Number 518654.

1-5. 1720A Fluke BASIC Programming Manual

1-6. The Programming Manual provides a description of the Fluke-Enhanced ANSI-standard BASIC language developed for the 1720A Instrument Controller. It is arranged by subject, and combines readable syntax diagrams with numerous examples. Emphasis is on instrumentation system control using effective programming techniques. This manual presumes familiarity with the 1720A User Manual. Order Fluke Part Number 518670.

1-7. 1720A BASIC Reference Guide

1-8. The BASIC Reference Guide is a pocket-size quick reference guide that summarizes the most often used contents of the User and BASIC Programming manuals. Order Fluke Part Number 526210.

1-9. HPL to Fluke BASIC Handbook

1-10. A specialized manual for the programmer who is familiar with the Hewlett-Packard 9825 Calculator using the HPL language. Building upon this familiarity, the handbook describes functional similarities and differences, and leads the programmer through the task of converting existing HPL programs for operation on the 1720A Controller. Order Fluke Part Number 546341.

1-11. 1720A Display Worksheet Pads

1-12. The 1720A display worksheets have a grid pattern that shows both normal and double size character positions, and the touch sensitive areas of the display. This allows the programmer to design effective display layouts. They are available in pads of 50. Order Fluke Part Number 533547.

1-13. 1720A Operator Manual

1-14. The Operator Manual is a brief manual for the operator of a programmed 1720A-controlled system who will not normally use the keyboard. It discusses such subjects as proper disk handling and error interpretation, and includes an error and trouble-indicent log. Order Fluke Part Number 518647.

1-15. 1720A Service Manual

1-16. The Service Manual includes component level theory of operation for each hardware module, with diagnostic procedures that can resolve failures to the modular level. Schematics and parts lists are provided. Order Fluke Part Number 518662.

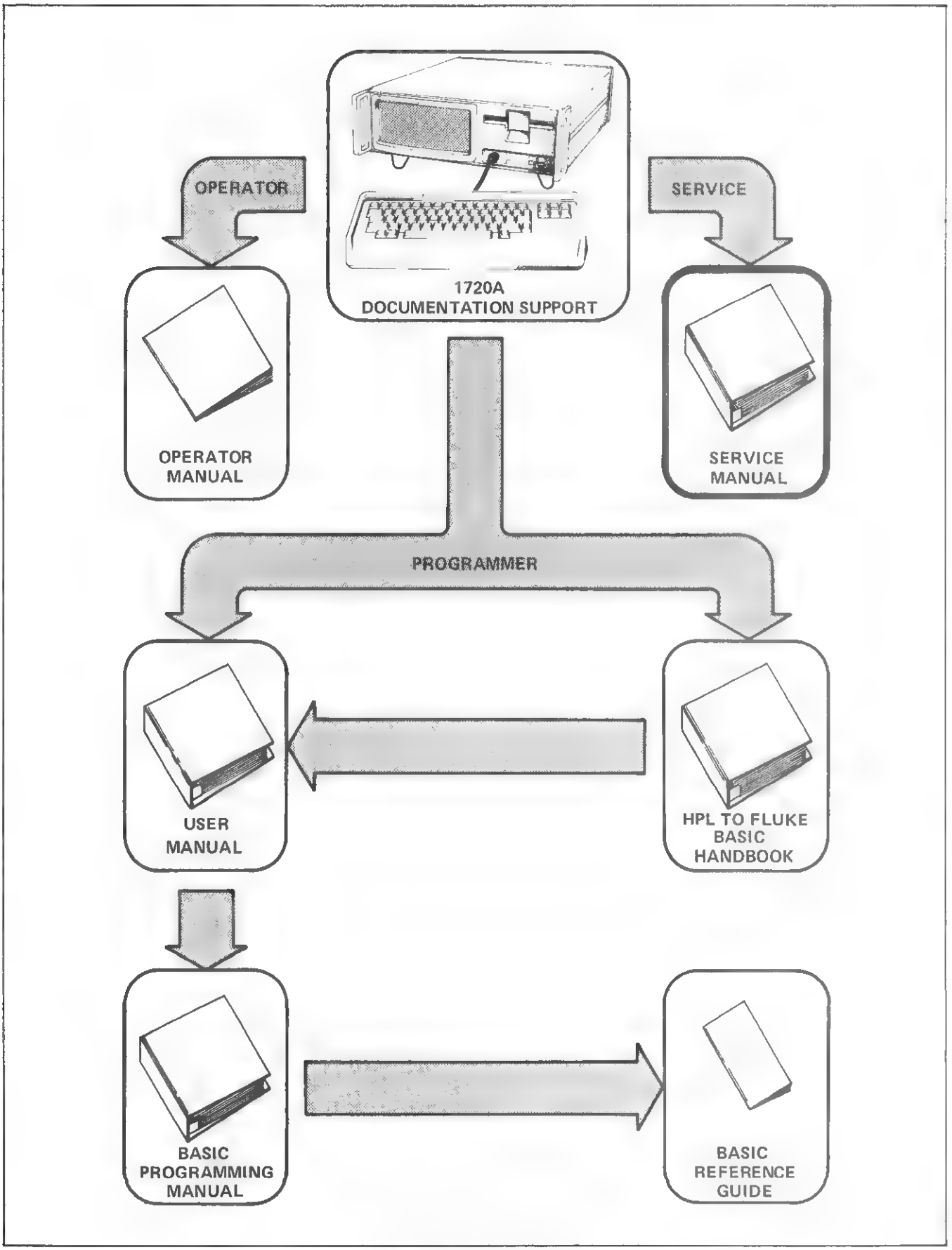

Figure 1-1. Manual Set

1-17. INTRODUCTION TO THIS MANUAL

1-18. The 1720A Service Manual is intended to be a reference source for the Customer Service Engineer. The component-level theory of operation is divided into a series of subsections. The first of these sections, Section 2, is an overview of the entire system. This section presents an overall functional description of the 1720A. Each of the subsections that follows Section 2 gives a detailed theory of operation for a particular system module or functional group of modules. Each of these subsections has an introduction that ties its detailed theory of operation into the overview in Section 2.

1-19. The Maintenance Section, Section 3, begins with a performance verification procedure that allows the user to verify that the system is performing correctly. This performance verification procedure is followed by a modular level diagnostic procedure and assembly/disassembly procedures that can resolve and enable repair of failures to the modular level. The last two sections of the manual contain the parts lists and schematics.

1-20. SPECIFICATIONS

1-21. Refer to Table 1-1 for the 1720A Instrument Controller specifications. In addition to these specifications, the 1720A has the following features:

- Touch-sensitive display for operator which serves as a dynamic, tutorial, programmer-defined "keyboard"
- Detachable programmer's keyboard
- Rackmountable
- Two character sizes, programmable
- 128K or 256K byte E Disk (electronic disk) optional (K = 1024)
- 60K bytes of read/write memory with byte parity 175K-byte mini-floppy disks for archives and back-up
- Real time and calendar clock
- Dual IEEE-488 interfaces, standard
- Dual RS-232-C interfaces, standard
- Composite video output, standard

Table 1-1. 1720A Specifications

GENERAL SPECIFICATIONS	
Operating Temperature	10°C to 40°C
Storage Temperature	−10°C to +60°C for 1720A, +10°C to +52°C for floppy disks
Relative Humidity (Operating)	8% to 80%
Relative Humidity (Non-operating)	5% to 95%, non-condensing; 8% to 90% for floppy disks, non-condensing
Size	14.6 cm H x 43.18 cm W x 62.24 cm L including feet and handles (5.25 in H x 17 in W x 20.5 in L)
Weight	Controller 16 kg (35 lbs.); Keyboard 1.4 kg (3 lbs.)
Power	90V to 132V at 47 Hz to 63 Hz, 192V to 250V at 47 Hz to 63 Hz, 104V to 126V at 380 Hz to 420 Hz
CRT DISPLAY SPECIFICATIONS	
Scanning Method	Non-interlaced raster scan
Refresh Rate	60 Hz at all times
Refresh Memory	1280 bytes of dedicated display memory: 16 lines of 80 characters each.
CRT Screen	High contrast green phosphor, 12.7 cm x 22.9 cm (5 in x 9 in) low profile, rectangular
Screen Capacity	16 x 80 cells, or 8 x 40 cells
Standard Character Set	128 ASCII characters
Character Font	7 x 9 in an 8 x 14 matrix
Highlighting Capability	Inverse video, blinking, underline, and highlighting
Cursor	Blinking underline standard
Alpha Raster Size	7.6 cm x 19 cm (3.0 in x 7.5 in)
Screen Brightness	Adjustable with rear control
Cell Size	Double size, 4.8 mm x 5.5 mm (0.188 in x 0.375 in). Standard size, 2.4 mm x 2.8 mm (0.094 in x 0.188 in)
Character Size	Double size, 4.2 mm x 5.4 mm (0.164 in x 0.241 in). Standard size, 2.1 mm x 2.7 mm (0.082 in x 0.121 in)

Section 2
Theory of Operation

2-1. INTRODUCTION

2-2. This section presents an overall functional description that is intended to give the general concept of what the Controller is and how the modules within it work together. The detailed theory that follows introduces each of the system modules by tying the functions each module performs into the overall functional description. This is followed by a description of how the circuits within that module implement each of those functions. By considering a system malfunction in terms of symptoms that relate to these functions, the Customer Service Engineer can go directly to the pertinent description.

2-3. OVERALL FUNCTIONAL DESCRIPTION

2-4. The Model 1720A is designed for use as a programmable Instrument Controller in a multiple instrument system using the IEEE-488 Bus. In the capacity of controller, it is capable of sending universal commands and addressed commands and addressing devices on the bus to designate talkers and listeners. The user programs are written in BASIC and stored in and executed from a 60K byte Memory module. They give the 1720A the ability to process collected data, format the results to meet unique user needs, make decisions based on events, and respond to instrument service requests with user specified routines.

2-5. In addition to this main function, the 1720A stores programs and data on a built-in floppy disk and provides two general purpose RS-232-C I/O Ports which can interface to many devices including printers and modems. The 1720A can operate up to two optional 128K byte Electronic Disk Modules which provide electronic disk-like storage.

2-6. The programmer enters programs via a detachable keyboard. The system software communicates with the programmer via a CRT display. After entering these programs, the programmer can store them on floppy disks or the Electronic Disk and load them from disks from then on.

2-7. The operator operates the system with the keyboard detached by using the Touch-Sensitive Display. This permits the operator to respond to directions from the program which appear on the CRT display and to give inputs to the system by touching specific points on the CRT face.

2-8. System Software

2-9. The 1720A System Configuration is shown in Figure 2-1. The system software consists of the FDOS (Floppy Disk Operating System), the Console Monitor, the BASIC Interpreter, a ROM Loader, plus the File Utility or other utility program. The user can write programs in BASIC which are stored in, and executed from the Memory module. These programs enable the 1720A to function as a programmable instrument controller with data processing capabilities. FDOS allows programs and data to be stored on the built-in floppy disk. Consult the User Manual for a complete discussion of these capabilities.

2-10. 32K Word Main Memory

2-11. The main memory, located in the Memory Module, has a 32K word capacity. These words are accessed at even memory addresses by the CPU Module; however, 2K words of the main memory cannot be accessed by the user. This 2K of address space accesses 2K of memory in the CPU Module itself called scratch pad RAM. The discussion on the CPU Module covers this overlay of address space in detail. Each word in the main memory consists of two 8-bit bytes giving the memory a user capacity of 60K bytes. Bytes are treated by the system as odd and even bytes during DMA (Direct Memory Access) operations by the Floppy Disk Module. During these data transfers, the odd byte is accessed with an odd address.

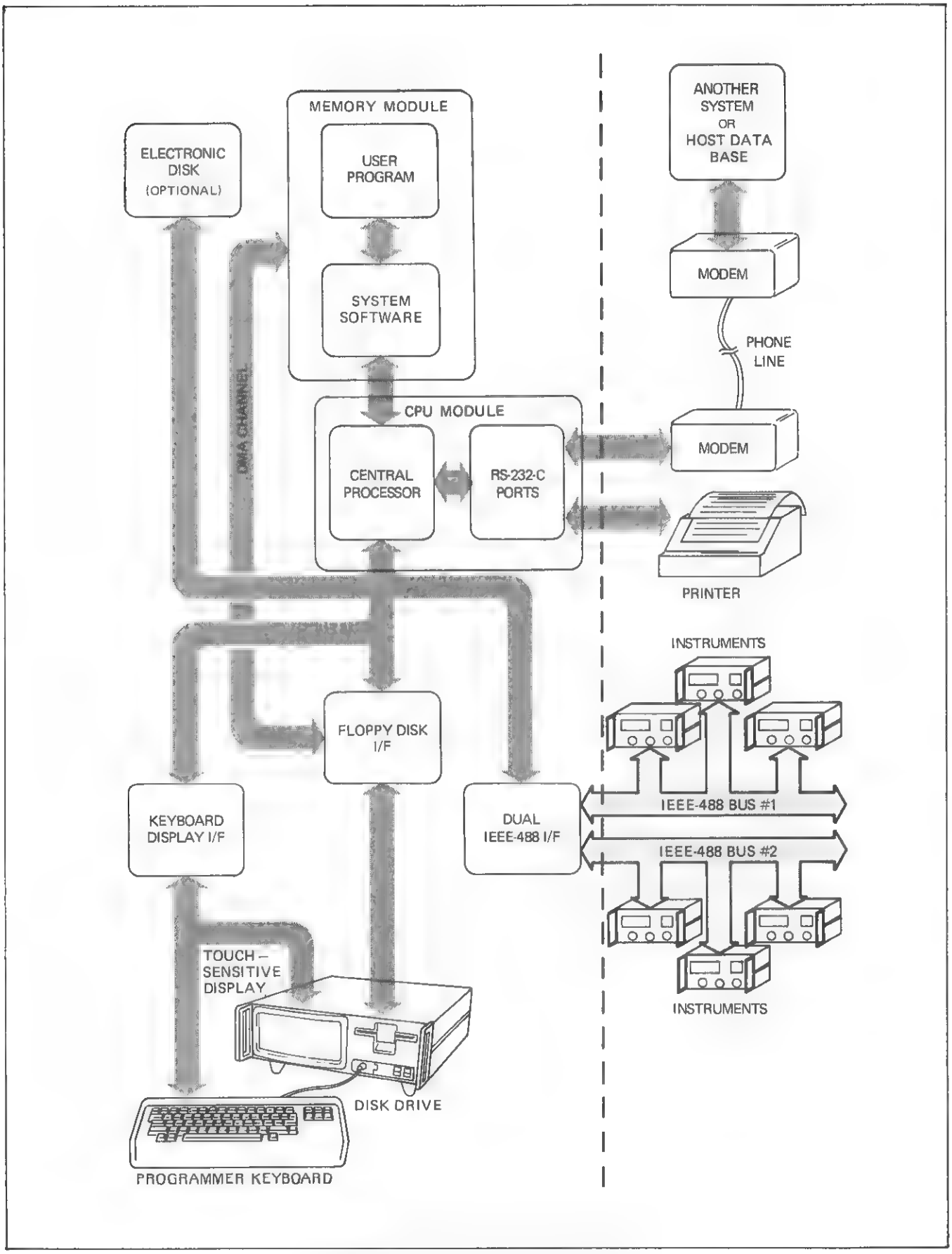

Figure 2-1. 1720A System Configuration

2-12. Control of Peripheral Devices

2-13. As shown in Figure 2-1, the 1720A can control external instruments via two independent IEEE-488-1978 buses. Up to 15 devices can be controlled on each IEEE bus (including the Controller). It is through these two interfaces that the 1720A carries out its primary function of instrument control under the direction of the user program.

2-14. Data Processing

2-15. The 1720A contains a CPU Module that has a Central Processor which incorporates a complete mini computer instruction set. This module can process the data which the 1720A receives from the external devices and from the system operator. A full description of the capabilities available to the user/programmer can be found in the User Manual.

2-16. Serial Data Capability

2-17. The 1720A has two RS-232-C ports. The interface for these ports is located on the CPU Module. As shown in Figure 2-1, these ports can interface the 1720A to many kinds of devices including a printer for direct data recording, a modem for data transfer, another system, or a host data base.

2-18. Floppy Disk Storage

2-19. The Floppy Disk Interface Module drives the built in floppy disk drive. This provides 175K bytes of user storage on a 5-1/4-inch double-density diskette. The Floppy Disk Module uses DMA (Direct Memory Access) data transfers for rapid storage and retrieval of data.

2-20. Programmer Keyboard and Touch-Sensitive Display

2-21. Both the Programmer Keyboard and the Touch-Sensitive Display pass data to and from the rest of the system via the Video/Keyboard Module. This Module communicates directly with the CPU Module via a unique serial interface called the CRU (Communications Register Unit) Bus.

2-22. Bus Structure

2-23. The 1720A is designed around four internal buses, as shown in Figure 2-2. They are:

1. Address Bus
2. Data Bus
3. CRU Bus
4. Control Bus

2-24. Table 2-1 provides a description of the bus signals. It lists the name, mnemonic, number of lines, driver type, and active level for every bus signal. Table 2-2 defines these signals. Refer to these two tables while reading this manual. Familiarity with the signals on these four busses is vital to the understanding of the 1720A.

2-25. Optional Electronic Disk

2-26. The optional Electronic Disk Module or E-Disk* has 128K bytes of memory capacity. Up to two Modules can be installed and the 1720A treats the pair as one large electronic disk. This gives a total capacity of 256K bytes. Unlike the Memory Module, each address in the Electronic Disk (both odd and even) contains one word. This leaves an Electronic Disk with its 128K byte capacity accessible by word only. In addition to this difference, the CPU Module accesses the Electronic Disk via Memory Mapped I/O operations instead of simple memory read/write operations.

2-27. Interrupts

2-28. The theory of operation for the CPU Module includes a detailed discussion on the handling of interrupts. This discussion only presents a brief introduction to the use of interrupts by the 1720A as an interrupt driven system. The term interrupt is defined as an attention signal sent to the CPU by another module to obtain service.

2-29. An interrupt occurs for a variety of reasons. For example, the depression of a key on the Programmer Keyboard. When this happens, the Video/Keyboard Module needs to send the code of this key to the CPU Module. After the CPU Module asserts (brings low) the RINT- (Refresh/Interrupt) control line, the Video/Keyboard Module pulls its assigned data line low.

2-30. The CPU carries out a programmed response to each of the interrupts on the data bus according to their priority; data bit 0 (DI00) has the highest priority, and data bit 15 (DI15) has the lowest. If the priority of the interrupt is higher than the one the CPU is servicing at the time of the interrupt, the CPU suspends processing of that interrupt and services the new interrupt. When done, it returns to process the original interrupt, provided no new interrupts of a higher priority occur. This nesting of interrupts can go on indefinitely.

* E-Disk is a trademark of the John Fluke Mfg. Co., Inc.

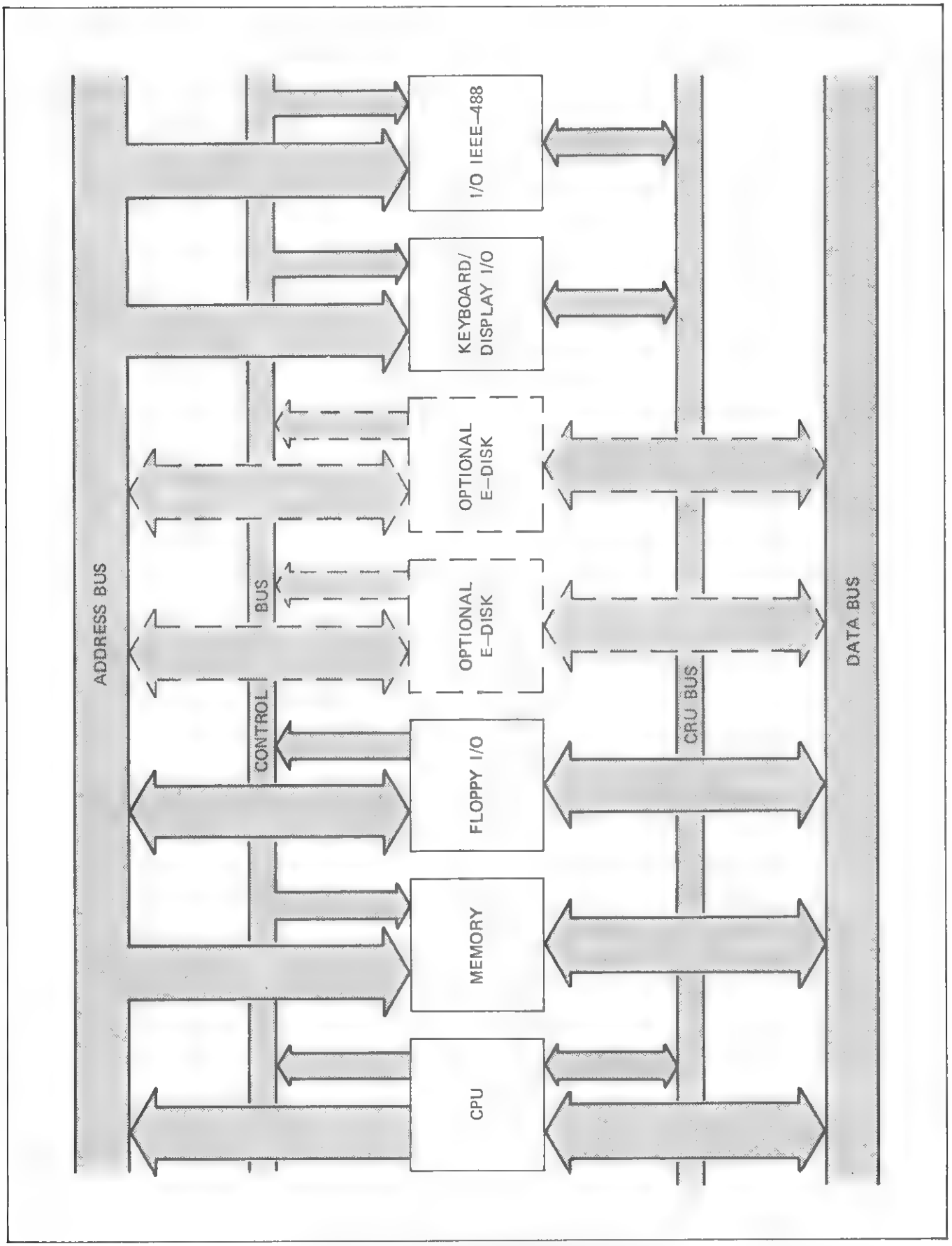

Figure 2-2. 1720A Controller Internal Buses

Table 2-1. Bus Signals

NAME	MNEMONIC	NUMBER OF LINES	TYPE OF DRIVER	ACTIVE LEVEL
Address Bus	A00-A19	20	Tri-State Buffer	High
Data Bus	DI00-DI15	16	Tri-State Buffer	High
CRU Bus				
CRU Input	CRIN	1	Open Collector	High
CRU Output	CROUT	1	TTL Buffer	High
CRU Clock	CRCLK-	1	TTL Buffer	Low
CRU Address Acknowledge	CRACK-	1	Open Collector	Low
Control Bus				
Address Valid	ACVAL-	1	Tri-State Buffer	Low
Address Acknowledge	ADACK-	1	Open Collector	Low
Bus Write	BUSWR-	1	Tri-State Buffer	Low
Refresh-Interrupt	RINT-	1	Tri-State Buffer	Low
Bus Request In	RQIN-	1	TTL	Low
Bus Request Out	RQOUT	1	TTL	Low
Bus Grant In	GRIN	1	TTL	Low
Bus Grant Out	GROUT-	1	TTL	Low
Clock Sync	SYNC	1	TTL Buffer	N/A
Byte Mode	BMODE	1	TTL	Low
Hardware Error	HERR-	1	Open Collector	Low
Bus Clear	BCLR-	1	TTL Buffer	Low
ACOK	ACOK	1	TTL Buffer	High
DCOK	DCOK	1	TTL Buffer	High
Test	TEST-	1	TTL Buffer	Low
Halt	HALT-	1	Open Collector	Low
Power Supply Lines				
+5 Volts	+5V	2		
+12 Volts	+12V	2		
Logic Common	LCOM	8		
-12 Volts	-12V	1		
Battery Backed Up Supplies				
+5 Volts	+5VB	1		
-5 Volts	-5VB	1		
+12 Volts	+12VB	1		

Table 2-2. Bus Signal Definitions

SIGNAL NAME	DEFINITION
ADDRESS BUS	(A00-A19) - 20 lines used by the processor and Direct memory Access (DMA) devices to address a word of memory or an I/0 Register. The lower 12 bits (A00-A11) are also used for Communications Register Unit (CRU) addressing.
DATA BUS	(DI00-DI15) - 16 lines for data transfer throughout the system. In addition, when the Refresh-Interrupt control line is asserted, a device requests interrupt service by driving its assigned data bus line to the low (logic 0) state. Interrupts are prioritized with a request on data bit 0 (DI00) having the highest priority and data bit 15 (DI14) the lowest. Only one interrupting device is allowed per line.
ADDRESS VALID	(ADVAL-) - Indicates the presence of valid address information on the address bus. Also indicates that data on the DATA/INTERRUPT lines is true during processor write operations.

Table 2-2. Bus Signal Definitions (cont)

SIGNAL NAME	DEFINITION
ADDRESS ACKNOWLEDGE	(ADACK–) - Response line from an addressed memory or I/0 device. Must be asserted to indicate address recognition and allow processor (or DMA device) to procees with I/0 or memory operation.
BUS WRITE	(BUSWR–) - Indicates direction of data transfer on DATA/INTERRUPT lines. A low level indicates that processor (or DMA device) is sending data to the address I/0 or memory register.
REFRESH-INTERRUPT	(RRINT–) When asserted, indicates that interrupting devices may request interrupt service by driving the appropriate data line low. Dynamic memory devices use this line to initiate a refresh cycle.
BUS REQUEST IN	(RQIN–) - Active low request by device which wishes to control the bys (typically a high speed I/0 device). This line changes at each connector. It is called Bus Request Out (RQOUT–) as it leaves the connector, having passed through the device installed in that connector. From this connector, the line goes to the next higher priority device (closer to processor) where it will again be called Bus Request In (the processor has only a RQIN– line). The device which is physically closest to the processor has the highest request priority. Each device inhibits transfer of the RQIN signal to the RQOUT line if and only if it is also requesting the bus and no lower priority device has been granted the bus, signified by a low logic level on Bus Grant In (GRIN–).
BUS REQUEST OUT	(RQOUT–) - Active low signal to signify that a device is requesting control of the bus. This line will be asserted by the device to request bus usage or if the Bus Request In line is asserted. A device may not request the use of the bys if it has already been granted to a lower priority device signified by a low level on Bus Grant In. See also Bus Request In. A non-DMA device should connect Bus Request In to Bus Request Out to maintain continuity through the device.
BUS GRANT IN	(GRIN–)-Active low indication that the processor has places its tri-state bus drivers in the high impedance mode and entered the hold state. This line is broken at each connector and is called Bus Grant Out (GROUT–) as it leaves each device enroute to the next lower priority devie (further from processor), where it is called Bus Grant In.
BUS GRANT OUT	(GROUT–) - Each device normally transfers the logic state of the Bus Grant In line to the Bus Grant Out line. A device inhibits this transfer only when it is requesting or has been granted control of the bus. At this time, the Bus Grant Out line is maintained at a logic high level. Non-DMA devices shouldconnect Bus Grant In to Bus Grant Out to maintain continuity of the grant signal.
CLOCK SYNC	(SYNC) - Six megahertz clock.
BUS CRU INPUT	(CRIN) - communications Register Unit (CRU) input line, sampled during execution of the Store Communications Register (STCR) and Test Bit (TB) instructions.
BUS CRU OUTPUT	(CROUT) - CRU output line. Serial data is placed on this line during execution of the Load Communication Register (LDCR), Set Bit to Zero (SBZ), and Set Bit to One (SBO) instructions. Data is valid when the CRU clock line is low.
CRU ADDRESS ACKNOWLEDGE	(CRCLK–) - Active low indication that valid data appears on the CROUT line. (CRACK–) - Active low response line from addressed CRU devices. Must be asserted by CRU device when its address is placed on the address bus.
HARDWARE ERROR	(HERR–) - Active low line indicates that a device has detected a fatal error, such as a memory parity error, during a read or refresh operation. Assertion of this line will initiate a processor load sequence immediately following the instruction being executed.
BUS CLEAR	(BCLR–) - A low level on this line indicates that the bus interface circuitry on all devices should be reset to the unaddressed and inactive state. BDLR– is active for 160 ns.
ACOK	(AC OK) - A high level indicates that the unit is receiving adequate ac power. A transition from the high to low state indicates that the unit may soon lose dc power and backup operations should commence.

Table 2-2. Bus Signal Definitions (cont)

SIGNAL NAME	DEFINITION
BYTE MODE	(BMODE) - A low level indicates that the bus master is expecting data in byte format. DI08 through DI15 contain valid data. DI00 through DI07 are not used.
DCOK	(DC OK) - This line is intended for use as a power on/off reset. When this line as low all operation in the unit umst cease since the power supplies are close to falling out of regulation. The only exception will be circuitry capable of rumming off the battery supply (BATT).
TEST	(TEST-) - This signal enables those devices with special diagnostic circuits to enter a special mode of operation.
HALT	(HALT-) - This active low line will initiate a load sequence.

Section 2A
CPU Module

2A-I. INTRODUCTION

2A-2. The CPU Module gives the 1720A Controller the ability to accept user programs and carry out the intent of those programs. As shown in Figure 2A-1, the 1720A user works with the CPU Module, a piece of hardware, through three pieces of software: the User Program, the BASIC Interpreter, and the FDOS (Floppy Disk Operating System). This software resides in the 60K bytes of RAM in the Memory Module. The main function of the CPU Module is to decode and execute the various instructions that make up the software.

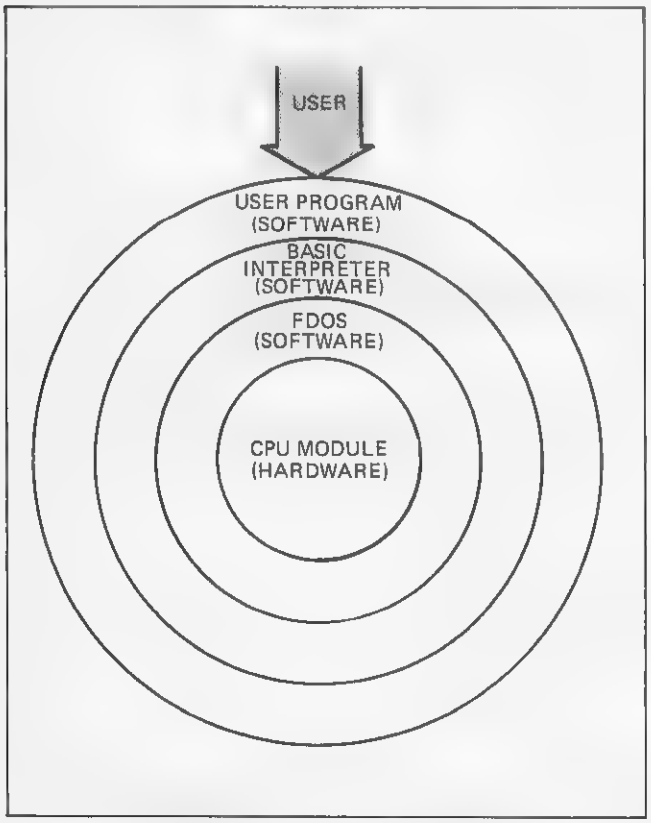

Figure 2A-1. CPU Environment

2A-3. It is important to know that the instructions the CPU receives from memory are in a special binary coded form called machine language and are part of the instruction set for the microprocessor. Refer to Figure 2A-2 and note that the microprocessor block is the main component of the CPU Module. This block is responsible for executing the user program and directing the activities of the CPU Module.

2A-4. In addition to decoding and executing instructions within the microprocessor instruction set, the CPU Module carries out other tasks. These tasks are discussed in the following paragraphs.

2A-5. Throughout the following discussion, the conventions listed below apply:

1. The same functional blocks appear on both the CPU schematic and the CPU Module block diagram.
2. Hexadecimal numbers indicate various boundries in memory or the bit patterns for codes.
3. The terms "vector" or "trap vector" refer to an address that points to the beginning of a program (including firmware routines) designed to handle a specific event, usually an interrupt. The adjective "trap" implies that a specific set of conditions leads to the vector.

2A-6. DECODING AND EXECUTING INSTRUCTIONS

2A-7. Overview

2A-8. The microprocessor receives the instructions it executes on the Internal Data Bus. This Bus receives data from three sources:

1. ROM
2. Scratch pad RAM
3. 1720A Data Bus (Memory Module)

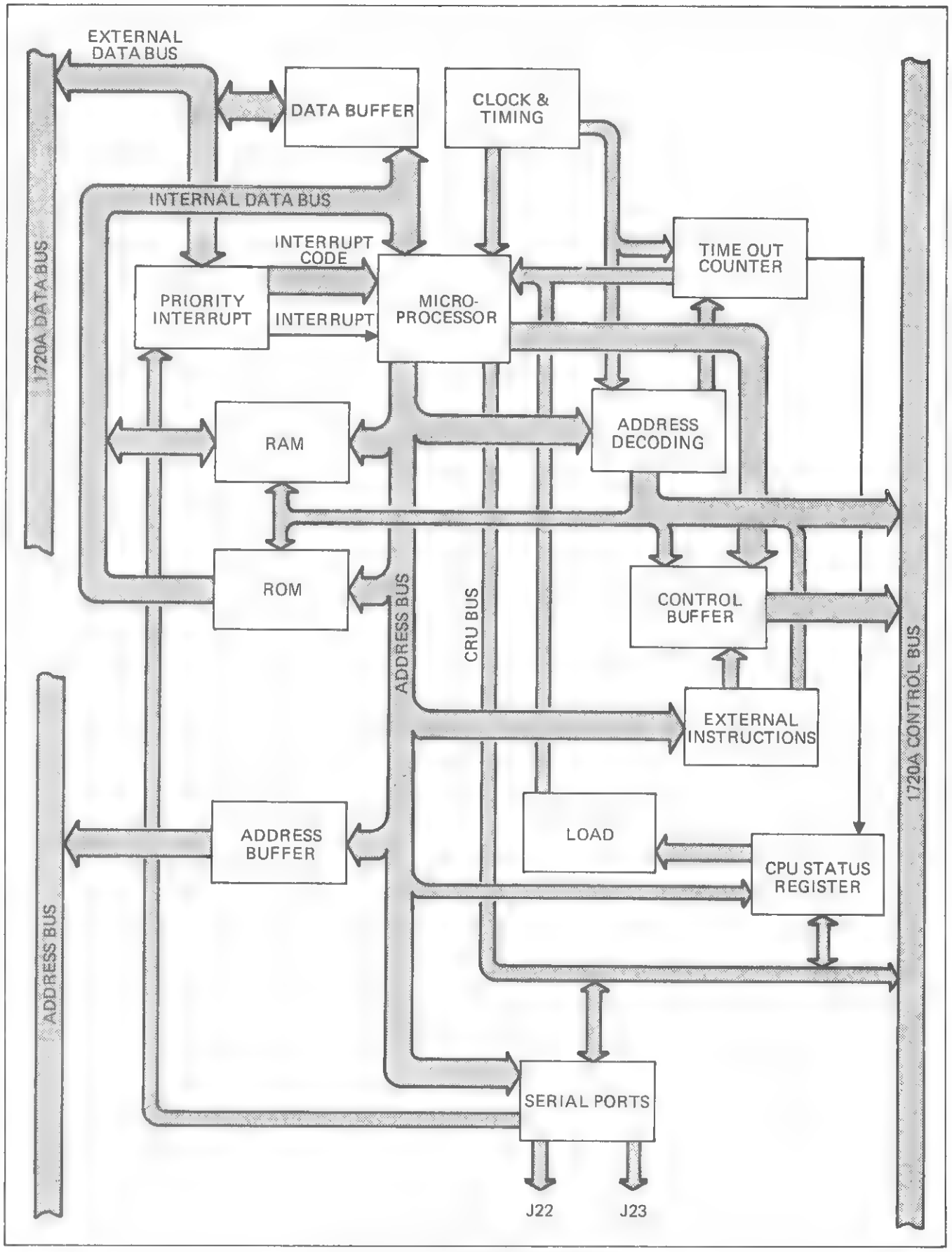

Figure 2A-2. CPU Module Block Diagram

2A-9. The actual transfer of both data and instructions to and from memory is covered later in this section. This topic covers only the way the microprocessor decodes and executes the instructions it receives. Each instruction performs one of the following operations:

1. Arithmetic, logic, compare, or bit/byte manipulation operations on data.
2. Loading or storage of internal registers (Program Counter, Workspace Pointer, or Status).
3. Serial data transfer between memory and external devices.
4. Control Functions, such as the External Instructions.

2A-10. Workspace Registers

2A-11. The microprocessor employs memory-to-memory architecture. Blocks of memory designated as workspaces replace conventional internal-hardware registers. Figure 2A-3 is a memory map that shows how the microprocessor views memory. The first 32 words are used for interrupt trap vectors. The next contiguous block of 32 memory words is used by the extended operation (XOP) instruction for trap vectors. The remaining memory is available for programs, data, and workspace registers. The special areas are available for general memory.

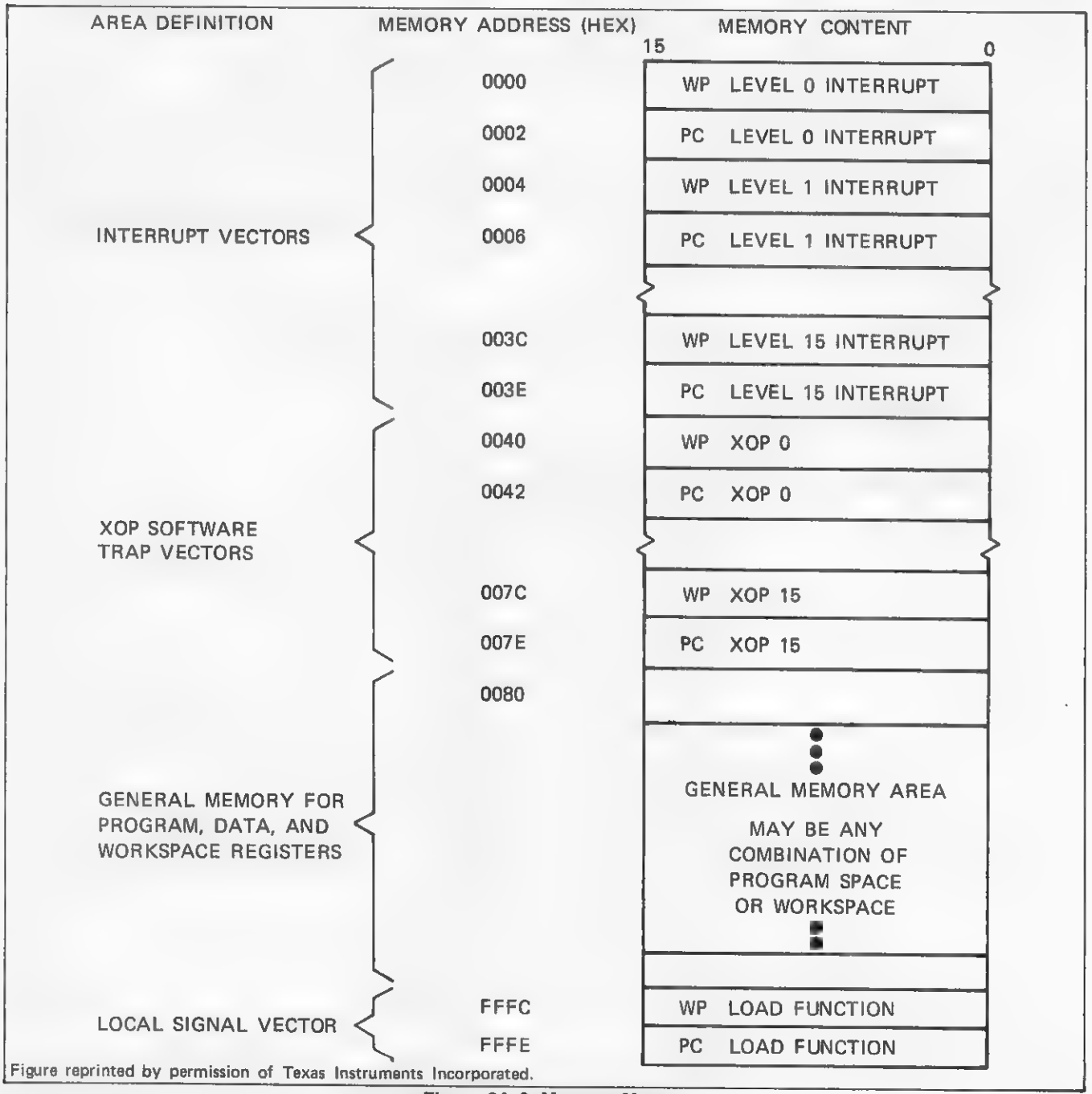

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Figure 2A-3. Memory Map

2A-12. Internal Registers

2A-13. Three internal registers are accessible to the assembly language programmer: the Program Counter, the Status Register, and the Workspace Pointer. The Program Counter (PC) contains the address of the next instruction to be executed. The microprocessor uses this address to fetch the next instruction from memory, and then increments it automatically or sets it to another value if the instruction under execution is a branch. The Status Register (ST) contains status information such as the interrupt mask level and information pertaining to the instruction operation (greater than, equals, overflow, etc.). This register is not to be confused with the status block shown in Figure 2A-2. The Workspace Pointer (WP) contains the address of the first word in the currently active set of workspace registers.

2A-14. Workspace Register File

2A-15. A workspace register file occupies 16 contiguous memory words in the general memory area. The individual workspace registers may hold data or addresses, and function as operand registers, accumulators, address registers, or index registers. During instruction execution, the processor addresses any register in the workspace by adding the register number (times two) to the contents of the workspace pointer and initiating a memory read or write operation. Refer to Figure 2A-4 and 2A-5.

2A-16. This workspace concept is useful during operations that require a context switch, which is a change from one program environment to another (as in the case of an interrupt response or a subroutine call). The microprocessor accomplishes a complete context switch with only three memory write operations and three memory read operations. After the switch, the workspace pointer may contain the starting address of a new 16-word workspace in memory for use in the new routine.

2A-17. Instruction Cycle

2A-18. Figure 2A-6 shows a flow chart of the instruction cycle for the microprocessor. This flow chart presents a pictorial representation of how the microprocessor accomplishes the fetch, decode, and execution of the instructions making up the software. The load and reset operations are described later in this section.

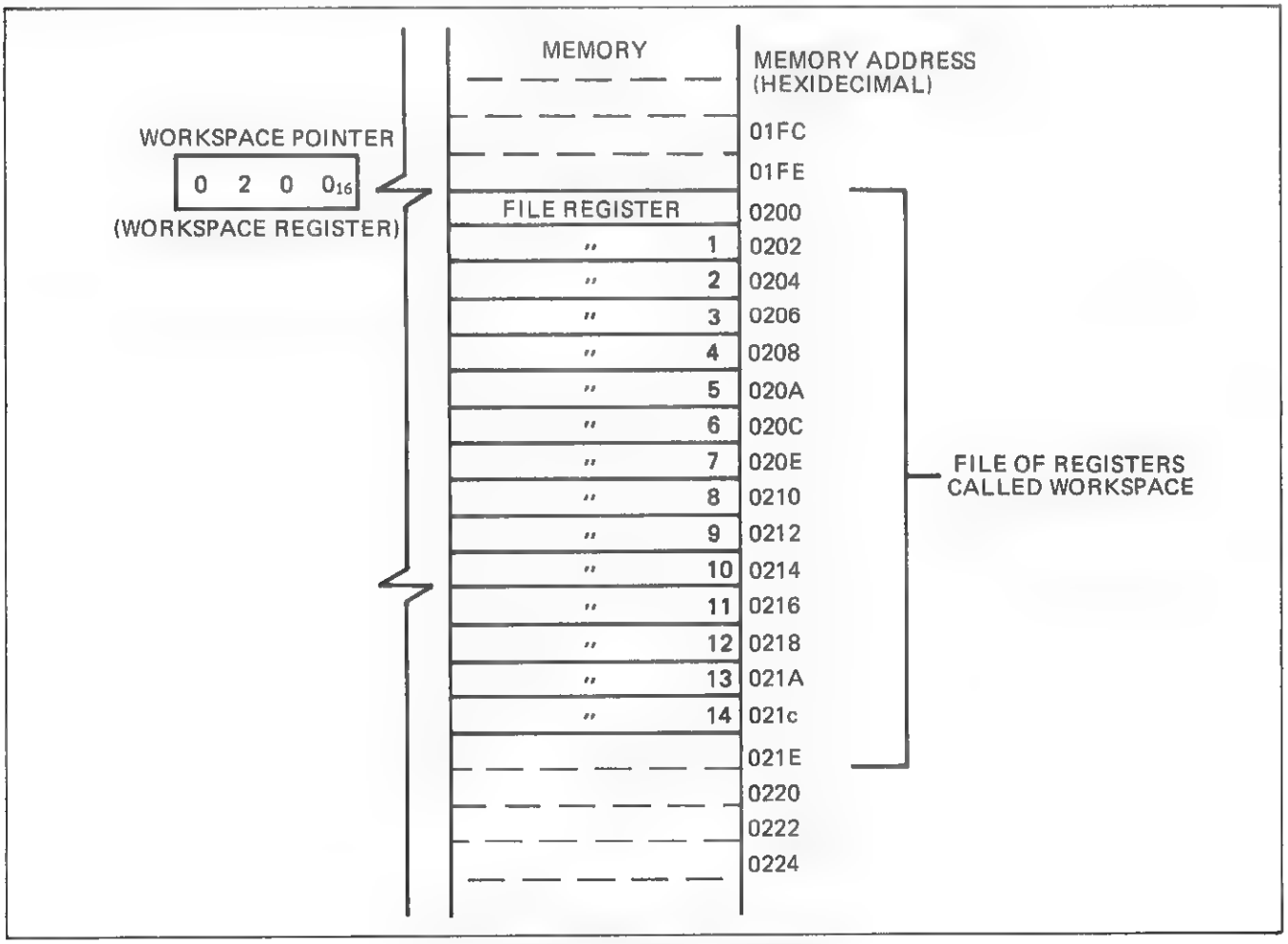

Figure 2A-4. Workspace Registers

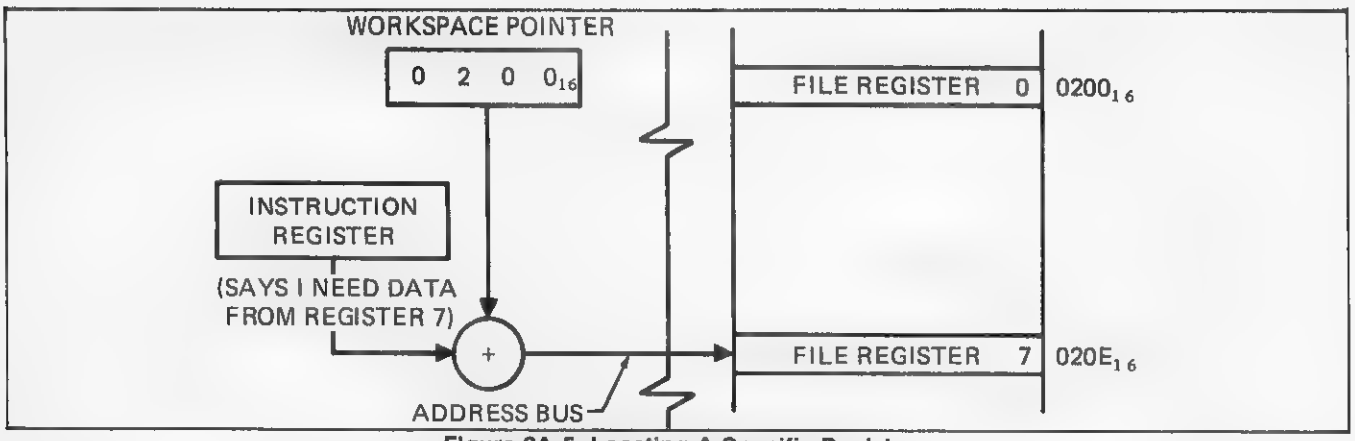

Figure 2A-5. Locating A Specific Register

2A-19. MEMORY DATA TRANSFERS

2A-20. The CPU Module initiates memory data transfers for three different purposes: data read operations, data write operations, and instruction aquisition. Read and write operations are often done in response to instructions in the software that are fetched from memory and decoded in the decoding and execution process. Refer to Figure 2A-7 for descriptions of the various microprocessor signals involved.

2A-21. Memory timing is shown in Figure 2A-8. The CPU Module goes through the following steps during memory data transfers:

1. Memory Enable (MEMEN-) goes active (low) during each memory cycle. At the same time that MEMEN- is active, the memory address appears on the microprocessor outputs AO through A14. Refer to Figure 2A-9. Notice that the microprocessor address bit numbering is reversed from the numbering on the Address Bus. Therefore, Address Bus bits ADRO1 through ADR15 carry the memory address with ADRO1 being the least significant bit and ADR15 being the most significant bit. If the cycle is a memory read cycle, DBIN (Data Bus In) goes active (high) at the same time MEMEN- and AO through A14 become valid. The memory-write signal WE- (Write-Enable) remains inactive (high) during a read cycle. If the read cycle is also an instruction Acquisition cycle, IAQ (Instruction Acquisition) goes high during the cycle. The write cycle discussion is in Step 4.

2. Refer to Figure 2A-2, CPU Module Block Diagram. The memory address goes through the Memory Address Buffer block to the 1720A Address Bus. It also goes to the ROM block and the Scratch Pad RAM. Figure 2A-10, Memory Area Selection, shows how this address is decoded to determine which portion of the addressable memory receives the address. The data from an addressed location within the Memory Module appears on the 1720A Data Bus and then on the Internal Data Bus. Data from a ROM or Scratch Pad RAM location appears directly on the Internal Data Bus. Use the following notes to study Figure 2A-10.

   a. OMS- (On-board Memory Strobe) goes active (low) for either a ROM or Scratch Pad RAM address and disables the Data Buffers to the 1720A Data Bus.

   b. ROM- (Read Only Memory) goes active (low) to enable the on-board ROM.

   c. RAM- (Random Access Memory) goes active (low) to enable the on-board RAM.

   d. IOMEN (Input/Output Memory) goes active (high) for address FXXX and above, to disable the Memory Module by setting address bits AD16 and AD17 true (high). ADOO through AD15 then address on-board memory (ROM and Scratch Pad RAM) or Memory Mapped I/O.

   e. DBIN active (high) gates data from the 1720A Data Bus to the Internal Data Bus through the Data Buffers, when OMS is not active (high).

3. At the end of the read cycle, MEMEN- and DBIN go inactive (high and low, respectively). The address bus may also change at this time; however, the data remains on the Input Bus for one clock cycle after the read cycle.

4. A write cycle is similar to the read cycle with the exception that WE- goes active (low), and valid write data appears on the Data Bus at the same time the address appears. This causes the Scratch Pad RAM to do a write cycle if addressed. DBIN is inactive (low) during a write cycle. Refer to Figure 2A-10. If the address goes off board, the low state of DBIN gates data through the Data Buffers onto the 1720A Data Bus and forces the control signal BUSWR- (Bus Write/Read-) low to indicate a write cycle to external memory devices. Note that WE- does not go out of the CPU Module, and that the Memory Module must generate its own write enable during a write cycle.

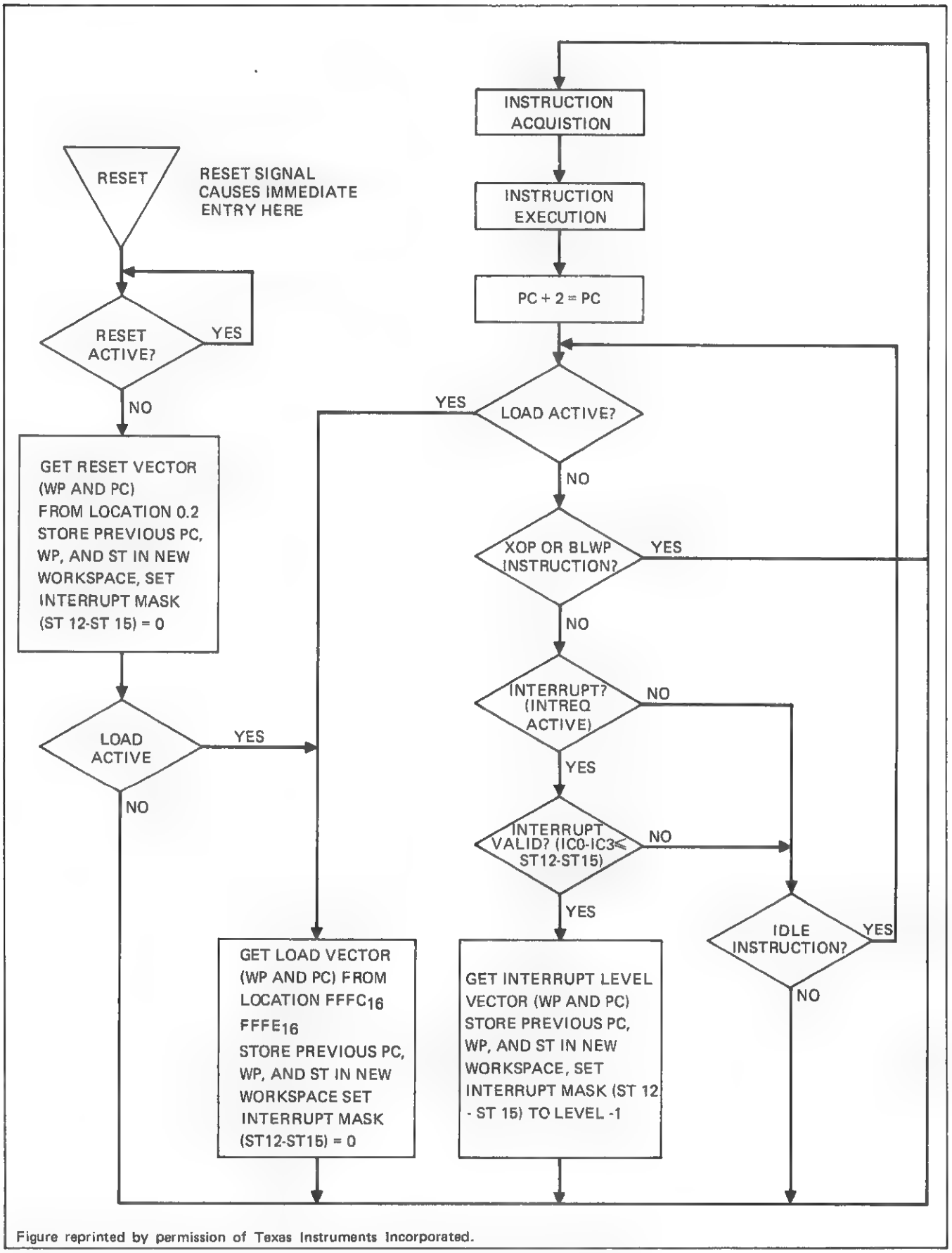

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Figure 2A-6. Microprocessor Flow Chart

SIGNATURE	PIN	I/O	DESCRIPTION
			ADDRESS BUS
A0 (MSB)	24	OUT	A0 through A14 comprise the address bus. This 3-state bus provides the memory-address vector to the external-memory system when $\overline{\text{MEMEN}}$ is active and I/O system when $\overline{\text{MEMEN}}$ is inactive. The address bus assumes the high-impedance state when HOLDA is active.
A1	23	OUT	
A2	22	OUT	
A3	21	OUT	
A4	20	OUT	
A5	19	OUT	
A6	18	OUT	
A7	17	OUT	
A8	16	OUT	
A9	15	OUT	
A10	14	OUT	
A11	13	OUT	
A12	12	OUT	
A13	11	OUT	
A14 (LSB)	10	OUT	
			DATA BUS
D0 (MSB)	41	I/O	D0 through D15 comprise the bidirectional 3-state data bus. This bus transfers memory data to (when writing) and from (when reading) the external-memory system when $\overline{\text{MEMEN}}$ is active. The data bus assumes the high-impedance state when HOLDA is active.
D1	42	I/O	
D2	43	I/O	
D3	44	I/O	
D4	45	I/O	
D5	46	I/O	
D6	47	I/O	
D7	48	I/O	
D8	49	I/O	
D9	50	I/O	
D10	51	I/O	
D11	52	I/O	
D12	53	I/O	
D13	54	I/O	
D14	55	I/O	
D15 (LSB)	56	I/O	
			POWER SUPPLIES
VBB	1		Supply voltage (-5 V NOM)
VCC	2,59		Supply voltage (5 V NOM). Pins 2 and 59 must be connected in parallel.
VDD	27		Supply voltage (12 V NOM)
VSS	26,40		Ground reference. Pins 26 and 40 must be connected in parallel.
			CLOCKS
$\phi 1$	8	IN	Phase-1 clock
$\phi 2$	9	IN	Phase-2 clock
$\phi 3$	28	IN	Phase-3 clock
$\phi 4$	25	IN	Phase-4 clock
			BUS CONTROL
DBIN	29	OUT	Data bus in. When active (high), DBIN indicates that the microprocessor has disabled its output buffers to allow the memory to place memory-read data on the data bus during $\overline{\text{MEMEN}}$. DBIN remains low in all other cases except when HOLDA is active.
$\overline{\text{MEMEN}}$	63	OUT	Memory enable. When active (low), $\overline{\text{MEMEN}}$ indicates that the address bus contains a memory address.

Figure 2A-7. Microprocessor Pin Assignments

SIGNATURE	PIN	I/O	DESCRIPTION
BUS CONTROL (cont)			
$\overline{WE}$	61	OUT	Write enable. When active (low), $\overline{WE}$ indicates that memory-write data is available from the microprocessor to be written into memory.
CRUCLK	60	OUT	CRU clock. When active (high), CRUCLK indicates that external interface logic should sample the output data on CRUOUT or should decode external instructions on A0 through A2.
CRUIN	31	IN	CRU data in. CRUIN, normally driven by 3-state or open-collector devices, receives input data from external interface logic. When the processor executes a STCR or TB instruction, it samples CRUIN for the level of the CRU input bit specified by the address bus (A3 through A14).
CRUOUT	30	OUT	CRU data out Serial I/O data appears on the CRUOUT line when an LDCR, SBZ, or SBO instruction is executed. The data on CRUOUT should be sampled be external I/O interface logic when CRUCLK goes active (high).
INTERRUPT CONTROL			
$\overline{INTREQ}$	32	IN	Interrupt request. When active (low), $\overline{INTREQ}$ indicates that an external interrupt is requested. If $\overline{INTREQ}$ is active, the processor loads the data on the interrupt-code-input lines IC0 through IC3 into the internal interrupt-code-storage register. The code is compared to the interrupt mask bits of the status register. If equal of higher priority than the enabled interrupt level (interrupt code equal or less than status register bits 12 through 15) the microprocessor interrupt sequence is initiated. If the comparison fails, the processor ignores the request. $\overline{INTREQ}$ should remain active and the processor will continue to sample IC0 through IC3 until the program enables a sufficiently low priority to accept the request interrupt.
IC0 (MSB) IC1 IC2 IC3 (LSB)	36 35 34 33	IN IN IN IN	Interrupt codes. IC0 is the MSB of the interrupt code, which is sampled when $\overline{INTREQ}$ is active. When IC0 through IC3 are LLLH, the gighest external-priority interrupt is being requested and when HHHH, the lowest-priority interrupt is being requested.
MEMORY CONTROL			
$\overline{HOLD}$	64	IN	Hold. When active (low), $\overline{HOLD}$ indicates to the processor that an external controller (e.g., DMA device) desires to utilize the address and data buses to transfer data to or from memory cycle.* The processor thenplaces the address and data buses in the high-impedance state (along with $\overline{WE}$, $\overline{MEMEN}$, and DBIN) and responds with a hold-acknowledge signal (HOLDA). When $\overline{HOLD}$ is removed, the processor returns to normal operation.
HOLDA	5	OUT	Hold acknowledge. When active (high), HOLDA indicates that the processor is in the hold state and the address and data buses and memory control outputs (WE, MEMEN, and DBIN) are in the high-impedance state.
READY	62	IN	Ready. When active (high), READY indicates that memory will be ready toread or write during the next clock cycle. When not-ready is indicated during a memory operation, the microprocessor enters a wait state and suspends internal operation until the memory systems indicate ready.
WAIT	3	OUT	Wait. When active (high), WAIT indicates that the microprocessor has entered a wait state because of a not-ready condition from memory.

Figure 2A-7. Microprocessor Pin Assignments (cont)

SIGNATURE	PIN	I/O	DESCRIPTION
			TIMING AND CONTROL
IAQ	7	OUT	Instruction acquisition. IAQ is active (high) during any memory cycle when the microprocessor is acquiring an instruction. IAQ can be used to detect illegal op codes.
LOAD	4	IN	Load. When active (low), LOAD causes the microprocessor to execute a nonmaskable interrupt with memory address $FFFC_{16}$ containing the trap vector (WP and PC). The load sequence begins after the instruction being executed is completed. LOAD will also terminate an idle state. If LOAD is active during the time RESET is released, then the LOAD trap will occur after the RESET function is completed. LOAD should remain active for one instruction period. IAQ can be used to determine instruction boundaries. This signal can be used to implement cold-start ROM leaders. Additionally, front-panel routines can be implemented using CRU bits as front-panel-interface signals and software-control routines to control the panel operations.
RESET	6	IN	Reset. When active (low), RESET causes the processor to be reset and inhibits WE and CRUCLK. When RESET is released, the microprocessor then initiates a level-zero interrupt sequence that acquires WP and PC from location 0000 and 0002, sets all status register bits to zero, and starts execution. RESET will also terminate an idle state. RESET must be held active for a minimum of three clock cycles.

Figure 2A-7. Microprocessor Pin Assignments (cont)

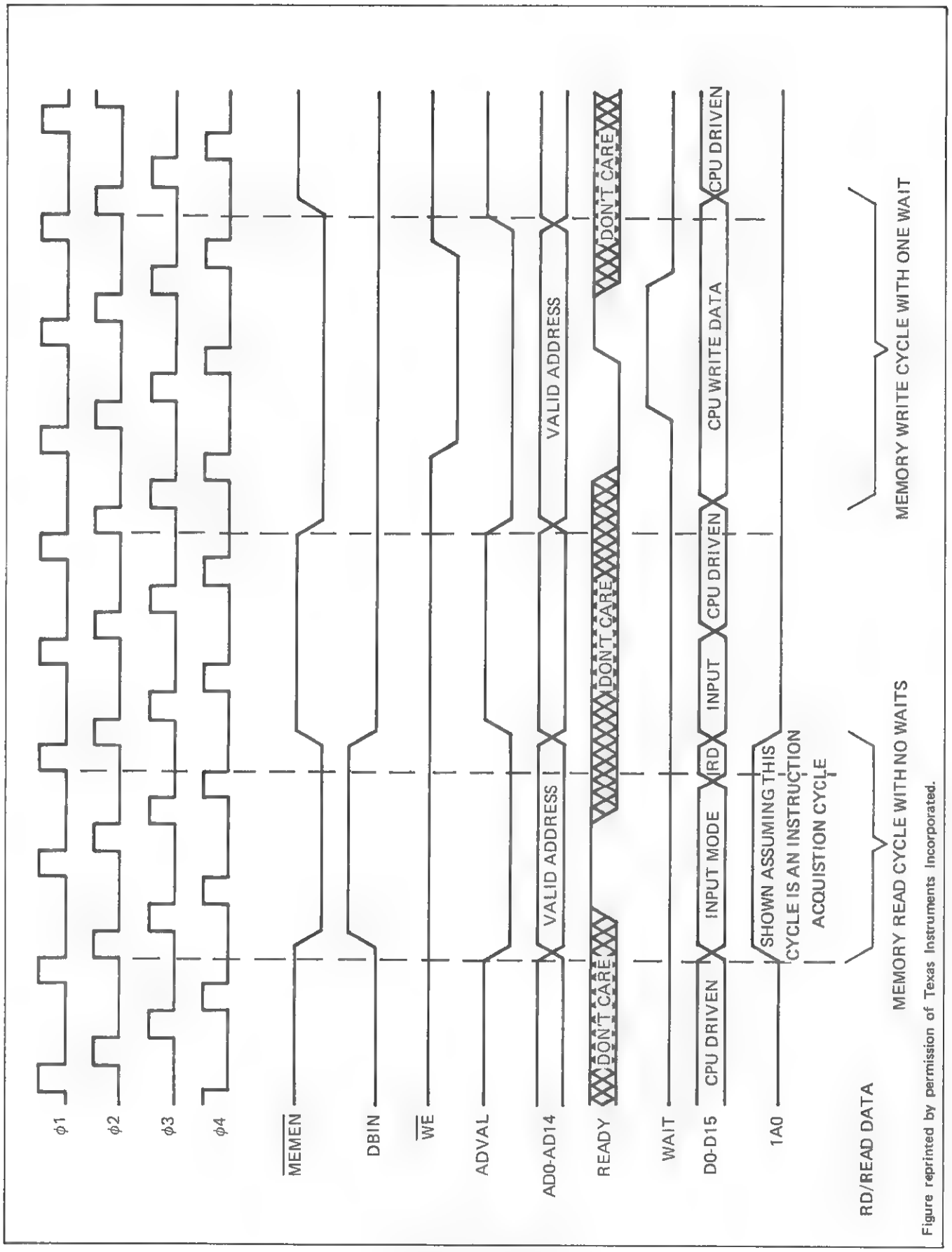

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Figure 2A-8. Memory Timing

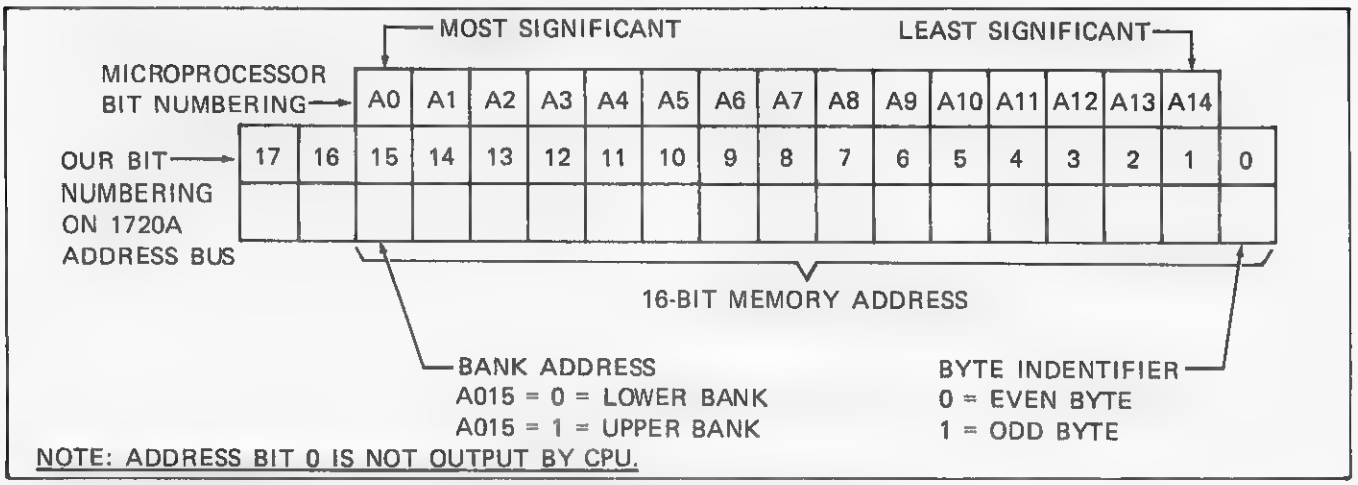


Figure 2A-9. CPU Address Bus

ADDRESS IN HEXIDECIMAL			ADDRESS ON ADDRESS BUS														MEMORY SELECTION	ACTIVE SIGNALS
			17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
2K WORDS	3	F F F F	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	CPU ROM	ROM- OMS- IOMEM AD16 · AD17 = 1
	3	F 8 0 0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0		
	3	F 7 F F	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	CPU SCRATCHPAD RAM	RAM- OMS- IOMEM AD16 · AD17 = 1
	3	F 6 0 0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0		
	3	F 5 F F	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	MEMORY MAPPED I/O	IOMEM
	3	F 0 0 0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0		AD16 · AD17 = 1
30K WORDS	0	E F F F	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	MEMORY MODULE UPPER BANK	DBIN- AD15 = 1
	0	8 0 0 0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		AD16 · AD17 = 1
	0	7 F F F	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	MEMORY MODULE LOWER BANK	DBIN- AD15 = 0
	0	0 0 0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		AD16 · AD17 = 1

Figure 2A-10. Memory Area Selection

2A-22. MEMORY MAPPED I/O OPERATIONS

2A-23. Refer to Figure 2A-10. For the addresses when IOMEM is active and OHM- is inactive (high), the CPU Module still carries out memory operations as described above. The only difference is that the CPU Module sends and receives data to and from I/O devices that respond to these addresses instead of memory. This allows the software to control I/O devices via the 1720A Address and Data Buses. See Electronic Disk Data Transfers for an example of memory mapped I/O operations.

2A-24. CRU IN/OUT DATA TRANSFERS

2A-25. In addition to the Memory Mapped I/O function mentioned previously, the CPU Module can send and receive serial data to and from devices (both on and off the CPU Board) via the CRUIN and CRUOUT lines from the microprocessor.

NOTE

CRUIN becomes CRIN outside the CPU Module, and CRUOUT becomes CROUT outside the CPU Module.

2A-26. The CRU interface timing is shown in Figure 2A-11. In all uses of the CRU (Communications Register Unit), the sequence of events is as shown in the following steps:

1. Address Bits ADRO1 through ADR12 carry 1 of 4096 possible addresses. This address goes to the 1720A Address Bus; and with some decoding, to the Status Block; and to the two Serial Ports.

2. If output operation is indicated, CRUCLK, from the microprocessor, goes active (high) and the microprocessor sets the CRUOUT line to a 1 or 0.

NOTE

CRUCLK becomes CRCLK outside the CPU Module.

3. If an input operation is indicated, CRUCLK remains inactive (high) and the addressed device places a 1 or 0 on the CRUIN line.

NOTE

An addressed device external to the CPU Module causes CRACK (CRU Address Acknowledge) to go active (low) when it recognizes the address.

2A-27. The signals CRIN and CROUT can transfer 1 to 16 bits per instruction cycle depending on the software instruction. For example, the two Serial Ports on the CPU Module and the IEEE-488 Module make use of the multi-bit feature and the Clock Module uses the single bit mode.

2A-28. ELECTRONIC DISK DATA TRANSFERS

2A-29. Transfers to and from the Electronic Disk are accomplished as described earlier in Memory Mapped I/0 operations. The concept involved, however, needs some additional explanation.

2A-30. Four memory locations are used to access registers inside the Electronic Disk. Refer to Table 2A-1.

2A-31. To write a file into the Electronic Disk, the software must go through the following steps:

1. Send an I/O Memory Mapped write address to the Electronic Disk Address Register (Register 1), placing the file address on the 1720A Data Bus.

2. Execute one Memory Mapped I/O write operation to the Electronic Disk Data Register (Register 3) for each word in the file. During this step, the electronics in the Electronic Disk automatically increments the Address Register to place each data word into consecutive addresses within the Electronic Disk.

2A-32. To read a data file from the Electronic Disk, the software must go through the following steps:

1. Send a Memory Mapped I/O write address to the Electronic Disk Address Register, placing the file address on the 1720A Data Bus.

2. Execute one Memory Mapped I/O read of the Electronic Disk Data Register for each word in the file.The CPU Module receives the data word on the 1720A Data Bus. While the CPU Module is completing this step, the Electronic Disk automatically increments the Address Register to read consecutive memory locations within the Electronic Disk.

2A-33. Each address (odd and even) in the Electronic Disk accesses one word (two bytes). This is different from the Memory Module where each address accesses one byte. In both cases the 16-bit Address Bus is capable of 64K addresses; however, those addresses contain twice as much data in the Electronic Disk.

2A-34. RESPONSE TO INTERRUPTS

2A-35. This discussion concerns itself with two kinds of interrupts:

1. Device Interrupts during RINT.

2. Reset and Load (non-maskable).

Table 2A-1. Electronic Disk Register Assignments

REG #	HEX ADDRESS	READ/WRITE	FUNCTION
1	F5C0	write	Low order address
2	F5C2	write	High order address
3	F5C6	write/read	Data
4	F5C6	write/read	Status/Control

Note: Address are for board #1. Register #2 is not used on board #1.

2A-36. Device Interrupts During RINT

2A-37. The CPU Module generates the RINT (Refresh-Interrupts) signal at least every 2 ms during the portion of each instruction that is involved with internal data processing (not using the Data or Address Buses). During a hold or a byte mode state, RINT occurs at the clock rate. These states come about when the microprocessor executes certain instructions. RINT goes out onto the 1720A Control Bus. Upon receiving RINT, any device that needs to interrupt the current program being run by the microprocessor pulls the 1720A Data Bus line assigned to it low. This limits the maximum possible interrupting devices to 16.

NOTE

It is only during RINT time that the 1720A Data Bus contains low-true interrupt addresses. Also note that it is during RINT cycles that the Memory Module refreshes the dynamic RAM chips in main memory.

2A-38. In the CPU Module the External Data Bus carrying the address of the interrupting device goes to the Priority Interrupt Logic. See Figure 2A-2. The Priority Interrupt Logic assigns the data bit O the highest priority and gives data bit 15 the lowest priority. The results appear on the four ICx inputs to the microprocessor. If the priority of the interrupting device is higher than the priority of the device the microprocessor is currently processing, the microprocessor does a context switch to the address contained in the corresponding interrupt vector location, and begins executing the service routine for the new device. Eventually, the microprocessor returns to finish processing the first device, providing no new interrupts of greater priority arrive.

2A-39. RESET and LOAD

2A-40. The Reset input to the microprocessor, RDCOK- (Reset DCOK), becomes active upon power on/off because it originates as the 1720A Control Bus signal DCOK (DC OK) from the Power Supply Module. When RDCOK- goes active (low) for a minimum of 3 clock cycles the microprocessor inhibits WE and CRUCLK. When RDCOK- goes high, the microprocessor initiates a level-zero interrupt sequence that acquires WP (Workspace Pointer) and PC (Program Counter) from locations 0000 and 0002. It also sets all status register bits to zero, and starts execution. The Reset input also terminates an idle state.

2A-41. The Load- input to the microprocessor is an output of the Load circuit block and goes active (low) when either of four status bits in the Status circuit are in a set state (Q output = 1). These bits are: HALT, HERR, TOERR, and ACOK (see Status Register later in this section). The active state of Load- occurs at the instruction acquisition time immediately following the setting of the status bit.

2A-42. When Load- goes active (low), the microprocessor executes a nonmaskable interrupt with memory addresses FFFC and FFFE containing the trap vector (WP and PC) after the current instruction is executed. In Addition, the microprocessor will also terminate an idle state. If Load- goes active (low) during the time Reset (RDCOK) is active, the microprocessor executes the LOAD trap after finishing the Reset function. Refer to the flowchart in Figure 2A-6. The Load vector leads to the cold-start loader program stored in read only memory (ROM).

2A-43. RESPONSE TO DMA REQUESTS

2A-44. All DMA devices request access to the 1720A Bus by setting the RQIN (Bus Request In) line to a 1 state (high). Inside the CPU Module, the Hold input to the microprocessor goes active (low) at the next RINT cycle.

2A-45. In response to the Hold signal, the microprocessor places its Address Bus and Internal Data Bus into the high-impedance state (along with WE, MEMEN, and DBIN) and sets HOLDA (Hold Acknowledge) high. This causes the Data Buffers and the Address Buffers in the CPU Module to go into the high impedance state and allow control of the bus by the requesting device (the DMA Floppy)

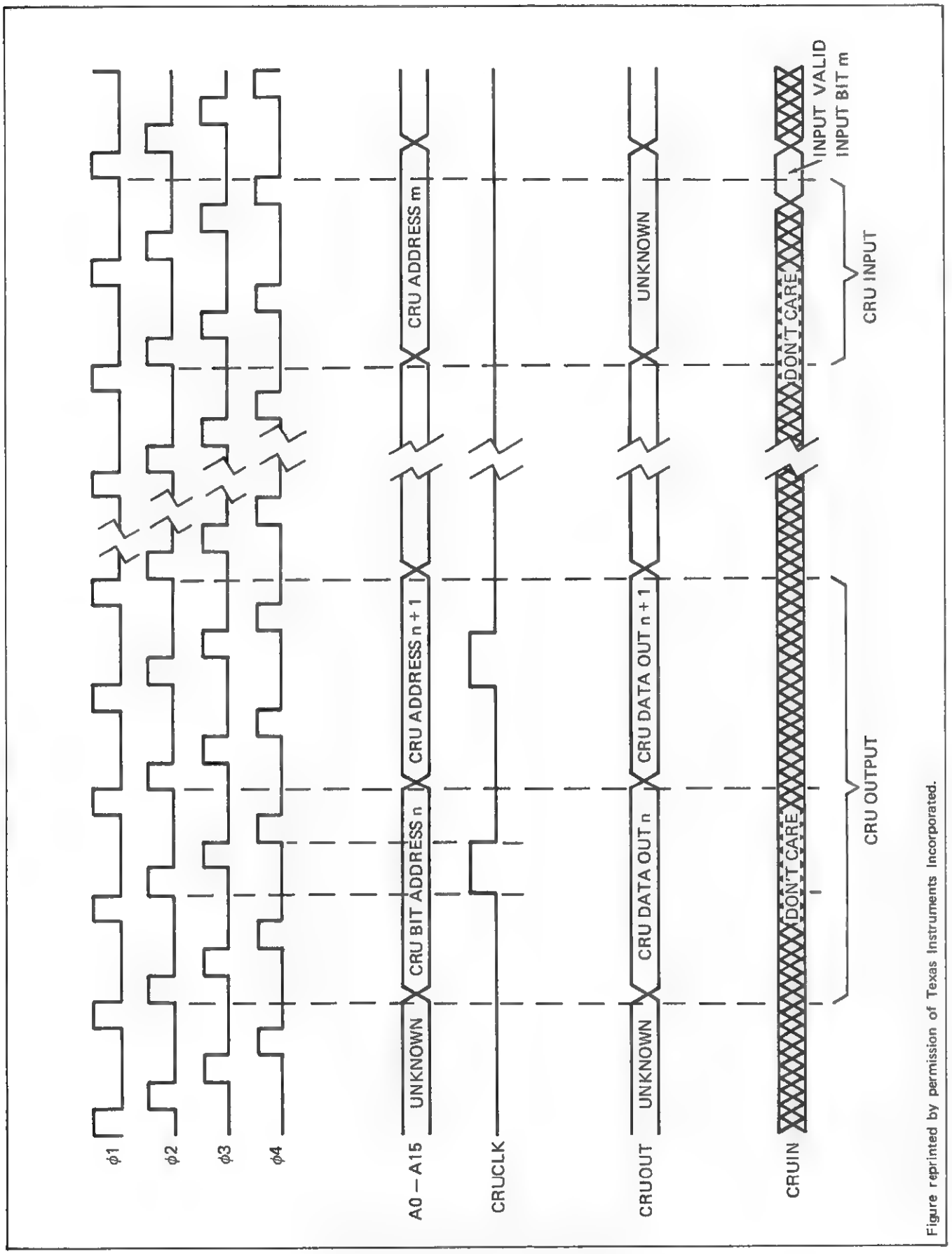


Figure 2A-11. CRU Interface Timing

2A-46. EXTERNAL INSTRUCTION LOGIC

2A-47. The microprocessor instruction set has five instructions which can be defined by the designer. When the microprocessor executes any of these five instructions, it places a unique three bit code on Address Bus lines AD15, AD14, AD13, and produces a CRICLK pulse. The codes and the 1720A defined functions appear in Table 2A-2.

2A-48. CPU CLOCK AND SYSTEM SYNC

2A-49. The Clock and Timing circuits of the CPU Module produces three groups of outputs. See Table 2A-3.

2A-50. TIME-OUT ERROR

2A-51. The time-out error process insures that the CPU accesses existing memory locations. Any time the CPU addresses memory outside the module and that particular memory device does not respond within a measured time limit, an error condition occurs.

2A-52. Refer to the Time-out Counter block on the schematic. Integreted circuit, U45 is a binary counter that is set to divide by 8. It is driven by 04, but held in the reset state (all zero output) by the high output of U44. This output stays active (high) as long as MEMEN- remains high. As soon as any memory cycle occurs, MEMEN- goes low (address valid) and the counter begins to count. The counter is reset by either OHM- or ADACK- through U44. If neither of these signals occurs before 8 block pulses, the TOERR (Time-out Error) signal goes active (high). This transition sets bit 2 in the Status block.

2A-53. RS-232-C SERIAL PORTS

2A-54. The two RS-232-C Serial Ports are identical and this discussion pertains to both. Refer to the Serial Port block on the schematic. When ADRO8 through ADR12 are all active (high) they enable U36, a decoder, that decodes ADR06 and ADR07, as follows:

ADRO6	ADRO7	OUTPUT ENABLE TO;
X	X	CPU Module Status Register
0	X	Serial Port #1
0	0	Serial Port #2

2A-55. Address bus bits ADR01 through ADRO5 act as inputs to U35 and U34, the Asynchronous Communication Controllers (ACC). The microporcessor uses these lines to select a particular function or mode within and ACC. After this, the ACC is ready to act as a port. When the microprocessor is sending data to the ACC, CRUOUT carries the data and CRUCLK acts as a strobe. When the microprocessor is reading data from theACC, CRUIN carries the data.

2A-56. The 1720A uses the two RS-232-C Serial Ports as data terminals. With this distinction in mind, review the RS-232-C port signal definitions in Table 2A-4.

2A-57. The ACC carries out all the necessary hardware functions for the transmission and reception of data. A software initialization routine uses the address bits ADR01 through ADR05 to set up the ACC internal registers: Control, Interval, Receive Data Rate, and Transmit Data Rate. Following this, the various port signals initiate a mode in the ACC, and the ACC produces an interrupt to the Priority Interrupt Logic. The microprocessor recognizes the interrupt (as discussed previously) and executes one of the software driver routines, shown below, as appropriate:

1. DSR generates an interrupt when going on or off (high or low).

2. CTS enables the transmitter section of the ACC when high.

3. CD same as CTS

4. REC transition from high to low enables the receiver circuitry.

2A-58. CPU MODULE STATUS REGISTER

2A-59. The microprocessor can read and reset any of the four status bits. The chart below describes the bit meanings. Refer to the Status Logic on the CPU Module Schematic and note that the status enable line from U36 in the Serial Port enables both U38 and U39. By executing a CRU operation to the correct address (ADRO6 through ADRO12), the microprocessor can read and reset any bit in the Status Register by placing the appropriate code on ADRO1 through ADRO3. Integrated circuit U38 decodes ADRO1 through ADF03 to select the status bit that goes onto CRUIN. Similarily, U39 decodes ADR01 through ADRO3 to reset that same bit on a later clock pulse.

2A-60. The Status register bits each have a particular meaning. Each is defined in Table 2A-5.

Table 2A-2. External Instructions

ADDRESS BUS			SIGNAL NAME ON 1720A BUS	FUNCTION	uP NAME
AD15	AD14	AD13			
1	1	1	HALT	HALT	LREX
1	1	0	TEST	Bus Test	CKOF
1	0	1	SSTEP	Single Step	CKON
0	1	1	BCLR	Bus Clear	RESET
0	1	0	IDLE	Idle	IDLE
0	0	0	CRU	CRU	CRU

Table 2A-3. Clock And Timing Outputs

GROUP NUMBER	OUTPUT	DESCRIPTION
1	$\phi 1$ $\phi 2$ $\phi 3$ $\phi 4$	MOS-level (0 and +12V) Four-phase clock output to the microprocessor.
2	1TTL- 2TTL- 3TTL- 4TTI-	TTL-level voltage (0 and 3.5V) Four-phase clock output to the Clock Bus.
3	SYNC	Clock signal for the system.

Table 2A-4. RS-232 Port Signal Definitions

J22/J23 PIN NUMBER	CIRCUIT*	SIGNAL NAME	SIGNAL MEANING	IN/OUT
1	AA	GND	Ground (Cable Shield)	--
2	BA	XMT	Transmit Data	OUT
3	BB	REC	Receive Data	IN
4	CA	RTS	Request To Send	OUT
5	CB	CTS	Clear To Send	IN
6	CC	DSR	Data Set Ready	IN
7	AB	RET	Signal Return (common)	--
8	CF	CD	Carrier Detect	IN
9	CD	DTR	Data Terminal Ready	OUT

* Taken from EIA Standard RS-232-C

Table 2A-5. CPU Status Register

BIT #	CONTROL SIGNAL	MEANING
4	DCOK	DC Supplies ready. Goes high approximately 0.5 seconds after power up, and goes low with any power shut down command.
3	ACOK	AC ready. Goes low as line power drops out for more than 30 ms or the ABORT switch in the Power Supply Remote Connector is set.
2	TOERR	Time-out Error.
1	HERR	Hardware Error. Usually the result of a detected memory parity error.
0	HALT	Halt

Note: The setting of S1, Baud Rate, is an input to U39 and is available during a read of the Status Register.

Section 2B
Memory Module

2B-1. INTRODUCTION

2B-2. The Memory Module provides a storage medium, for both programs and data, from which programs can be executed. A block diagram of the Memory Module is shown in Figure 2B-1.

2B-3. Certain words used in this description require definition. These words, and their meanings are:

1. A bit is a single binary digit.
2. A byte is 8 bits.
3. A word is 2 bytes.
4. K is the number 1024.

2B-4. MAIN MEMORY

2B-5. Dynamic RAM

2B-6. The 36 dynamic RAM ICs in the Main Memory each have 16K addressable locations that can hold 1 bit of information. Because these chips are dynamic, the Memory Module must perform a refresh operation every 2 ms to keep this information valid. The Transparent Refresh portion of this discussion covers the refresh operation in detail.

2B-7. Parallel Address And Data Lines

2B-8. Parallel address and data lines connect the memory ICs into one large array. This means that all ICs receive the same address and data inputs. A system of strobes determine exactly which ICs accept a given address and data. The on board strobe generation and the byte/word addressing portions of this discussion cover the use and generation of these strobes.

2B-9. Independent Upper And Lower Address Banks

2B-10. The independent upper and lower address banks each have a 16K word capacity. Refer to the main memory block diagram in Figure 2B-2 and note that it takes 1 RASxx strobe to access each byte in a given bank. During word mode operations, both of these strobes occur at the same time, and during byte mode they occur separately. The Byte/Word Addressing portion of this discussion covers this process in detail. Refer to Table 2B-1 for a definition of the strobe mnemonics. Then refer to Figure 2B-3 for an annotated layout of the RAM ICs that comprise the Main Memory.

2B-11. 7-Bit Chip Address Bus

2B-12. The 7-bit Chip Address Bus, which is the output of the Row/Column Decoder, provides the row/column address input to the Main Memory. Under the direction of the Row/Column Decoder, this bus first carries 1720A Address Bus bits AD08 through AD14 to make up the column address. It then carries bits AD01 through AD07 to make up the row address. As discussed earlier, the column address strobes and the row address strobes determine the chips which accept these addresses.

2B-13. Read And Write Operations

2B-14. The read and write operations both begin as soon as the chips receive the row address strobe. At this time, internal decoding within either 9 chips (byte mode) or 18 chips (word mode) in the addressed bank access the correct 1 out of 16K addresses within that bank. See the discussion of Byte Parity for an explanation of the extra bits in a byte and a word.

2B-15. During a read operation the Main Memory places the contents of the data locations onto the Data Output Bus and sends the contents of the parity locations to the Parity Generator/Checker.

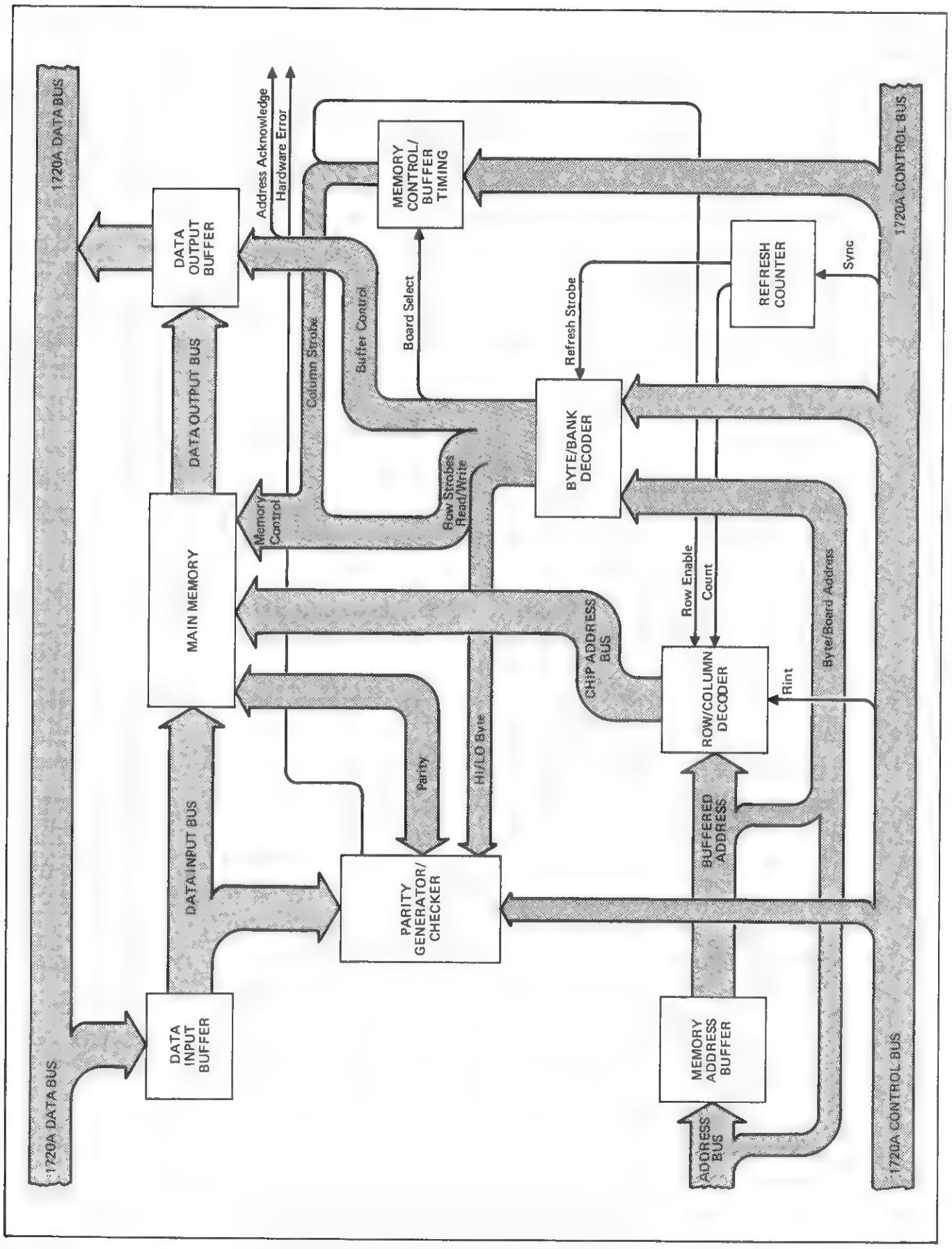


Figure 2B-1. Memory Module Block Diagram

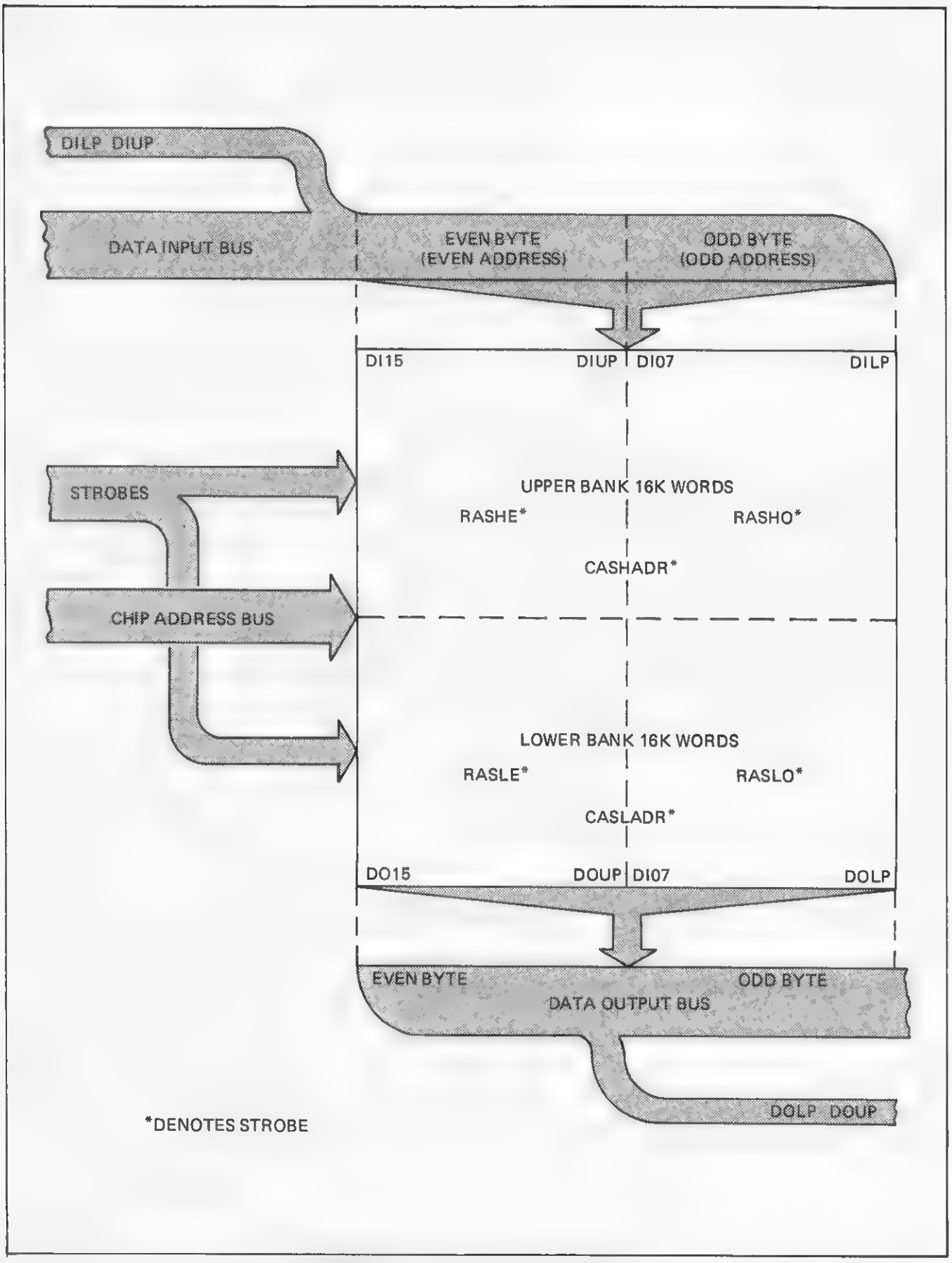


Figure 2B-2. Main Memory Block Diagram

Table 2B-1. Strobe Mnemonics

STROBE	MEANING
CASLADR-	Column Address Strobe, Low Addresses.
CASHADR-	Column Address Strobe, High Addresses.
RASLO-	Row Address Strobe, Low address bank, Odd byte.
RASLE-	Row Address Strobe, Low address bank, Even byte.
RASHO-	Row Address Strobe, High address bank, Odd byte.
RASHE-	Row Address Strobe, High address bank, Even byte.

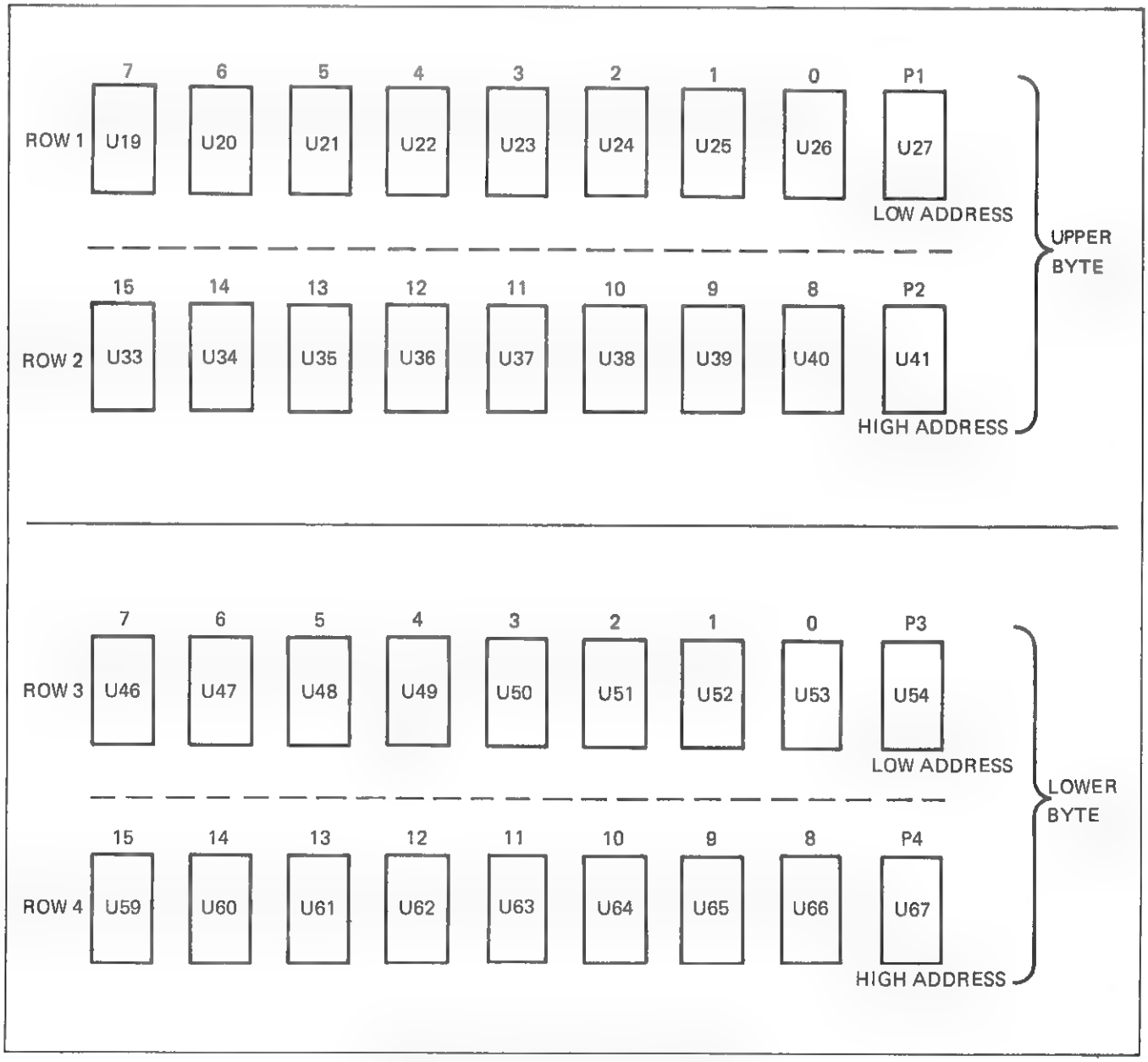


Figure 2B-3. Main Memory Chip Layout

2B-16. During a write operation, the Main Memory replaces the contents of the data locations with the contents of the Data Input Bus. It also replaces the contents of the parity locations with the output of the Parity Generator/Checker.

2B-17. BYTE/WORD ADDRESSING

2B-18. The Memory Module uses the register address strobes and the data out signals to accomplish byte/word addressing. There are 4 lines coming into the Memory Module that initiate and control this activity. They are:

1. BMODE- Byte MODE control (0 = byte mode)
2. BUSWR- Bus Write/Read (0 = write)
3. AD00 Address bit 0 (1 = odd byte)
4. AD15 Address bit 15 (1 = upper bank)

2B-18a. Refer to Table 2B-2 for the various strobes and output control signals that accomplish the actual byte/word addressing and control functions. See the Data Output Buffer discussion for an explanation of the mnemonics for DOE-, D00B-, and D00W-. Refer to the Byte/Bank Decoder section of the Memory Module Schematic for the logic elements involved.

TABLE 2B-2. Byte/Word Addressing and Control

BMODE	RASxx-/DOxx	AD00	AD15	BUSWR
=0 (byte)	RASLO	1	0	=0 (write)
	RASLE	0	0	
	RASHO	1	1	
	RASHE	0	1	
=1 (word)	RASLO-/RASLE	x	0	
	RASHO-/RASHE	x	1	
=0 (byte)	DOE	0	x	=1 (read)
	DOOB	1	x	
=1 (word)	DOE	x	x	
	DOOW-	x	x	
		x = don't care		

2B-19. TRI-STATE BUFFERS

2B-20. There are three sets of tri-state buffers in the Memory Module. Each set is described in the paragraphs that follow.

2B-21. Memory Address Buffer

2B-22. The Memory Address Buffer output goes to the Row/Column Decoder (AD01 - AD14), and to the Byte/Bank Decoder (AD00 and AD15). AD00 identifies bytes and AD15 identifies address banks.

NOTE

Although the buffers in the Address Buffer are the tri-state type, they function only as conventional buffers and are not used as tri-state devices.

2B-23. Data Input Buffer

2B-24. The Data Input Buffer operates in the word mode and in the byte mode. Turn to the Schematic (Data Input Buffer) and note the influence of the byte-mode control signal (BMODE-), as shown in Table 2B-3. The word-mode operation requires no explanation.

Table 2B-3. Data Input Buffer Mode Control

MODE	BMODE- STATE	BUFFERS USED
Word	1	U18, U42
Byte	0	U18, U45

2B-25. During byte mode, only the upper 8 bits of the 1720A Data Bus have data. The ground on pins 1 and 19 of U18 provides a constant enable. Therefore the data byte on the upper 8 bits of the 1720A Data Bus appears on both the lower and the upper 8 bits of the Data Input Bus (inside the Memory Module). This provides the same data input to both the odd and even sets of memory chips at the addressed location. Refer to Table 2B-2 and notice that BMODE-, AD00, and AD15 control which set of chips receive a RASxx strobe and store the data.

2B-26. Data Output Buffer

2B-27. The Data Output Buffer operates in word or byte mode as determined by the buffer control lines. During byte mode, only the upper 8 bits of the 1720A Output Bus carry data. This data can come from either the even or odd byte of a word location in the Main Memory. Each of the 3 buffers that make up the Data Output Buffer has a separate enable line. Refer to Table 2B-4, for an explanation of the Data Output Buffer Control lines.

Table 2B-4. Data Output Buffer Control

SIGNAL	FUNCTION
DOE-	Data output is even. Transfers a byte to 1720A Data Bus bits DI08--DI15.
DOOB-	Data output is odd, byte mode. Transfers a byte to 1720A Data Bus bits DI08--DI15.
DOOW-	Data output is odd, word mode. Transfers a byte to 1720A Data Bus bits DI00--DI07 in word mode.

2B-28. ON BOARD STROBE GENERATION

2B-29. The two circuits responsible for strobe generation are the Byte/Bank Decoder and the Memory Control/Buffer Timing. The discussion that follows covers these blocks.

2B-30. Byte/Bank Decoder

2B-31. The Byte/Bank Decoder has outputs that fall into six functional groups:

1. Address acknowledge signals
2. Word/byte mode control
3. Row address strobes
4. Parity check strobes
5. Output buffer control
6. Memory read/write control

2B-32. The address acknowledge signals ADACK- (Address Acknowledge) and BRDSEL (Board Select) act as follows:

1. ADACK- goes out to the 1720A Control Bus and is active when a given address is in the range of the Memory Module (AD16 and AD17 = 0).

2. BRDSEL occurs at the same time as ADACK- and initiates a memory operation in the Memory Control Buffer and Timing.

2B-33. The byte mode control output signal BMODE- (Byte Mode) controls buffer usage in the Data Input Buffer. Note that as an input signal to the Byte/Bank Decoder, BMODE- sets up the row address strobe outputs for the byte or word mode. See Table 2B-2.

2B-34. The Row address strobe signals (RASLE-, RASHO, and RASLO-) are described in Table 2B-1 and Table 2B-2.

2B-35. The Parity check strobes LOADDER- (Low Address Read) and HIADDER- (High Address Read) act as inputs to the Parity Generator/Checker, and strobe the two parity bits into the check circuits on a read operation.

2B-36. The Output buffer control signals (DOE-, D00B-, and D00W-) act as inputs to the Data Output Buffer, and control buffer usage as described earlier in this section.

2B-37. The Memory read/write control signals R/WHADR- (Read/Write High Address) and R/WLADR- (Read/Write Low Address) cause a read or write operation in the Main Memory block. They are set to a 0 state for a read and to a 1 state for a write.

2B-38. Memory Control Buffer And Timing

2B-39. As previously explained earlier under Independent Upper and Lower Address Banks, a sequence of events takes place during each memory operation. This sequence is under the direction of the Memory Control Buffer and Timing, which has four outputs. These outputs are:

1. RASEN is the Row Address Strobe Enable to the Byte/Bank Decoder.

2. RWEN (Row Enable) controls the Row/Column Decoder output to the Chip Address Bus. It is a 1 for the row address and a 0 for the column address. Refer to the Chip Address Multiplexing discussion later in this section.

3. CASLADR- is the Column Address Strobe Low Address to the Main Memory

4. CASHADER- is the Column Address Strobe High Address to the Main Memory.

2B-40. Refer to the Memory Control Buffer and Timing on the Memory Module schematic, and note that both column address strobes occur at the same time since they are outputs from two inverters (U12) which receive the column address each time the Main Memory is accessed (except during refresh operations).

2B-41. CHIP ADDRESS MULTIPLEXING

2B-42. The multiplexing feature of the memory chips allows the use of a 14-bit address, but requires only seven pins on the ICs. Chip address multiplexing of the incoming address occurs within the Row Column Decoder.

2B-43. Refer to the Row Column Decoder on the Memory Module Schematic. Multiplexer U57 responds to the state of the RWENA (Row Enable) line from the Memory Control Buffer and Timing block as follows:

1. RWEN = 0 Places the upper bits (AD08 - AD14) onto the Chip Address Bus (column address).

2. RWEN = 1 Places the lower bits (AD01 - AD07) onto the Chip Address Bus (row address).

2B-44. TRANSPARENT REFRESH

2B-45. To keep the Main Memory contents valid, a refresh of the dynamic cell matrix within each memory chip must be accomplished in each 2 ms time interval. This is done by performing a memory cycle at each of the 128 row addresses inside each chip. Although any normal memory cycle performs this refresh operation, row-address-only cycles most easily accomplish the function. Because the refreshing takes place during microprocessor RINT (Refresh/Interrupt) cycles when the CPU is not using the memory, the entire operation is transparent.

2B-46. Two circuits on the Memory Module are responsible for the refresh operation, the Refresh Counter and the Row Column Decoder. Both are discussed in the following paragraphs.

2B-47. Refresh Counter

2B-48. The Refresh Counter has two outputs which control the refreshing of the dynamic RAM ICs in the Main Memory block during microprocessor RINT cycles:

1. COUNT goes to a 0 state to increment the row refresh counter in the Row/Column Decoder.

2. REFSTRB-(Refresh Strobe) goes to the Byte/Bank Decoder and causes all four row address strobes to occur at once.

2B-49. Row Column Decoder

2B-50. The Row Column Decoder handles the refreshing of the dynamic RAMs in the Main Memory in addition to the multiplexing operation described earlier. Refer to the schematic and note that the signals RINT and COUNT are inputs to the multiplexer U57 in the Row/Column Decoder. These signals perform the following functions:

1. COUNT increments an internal counter which determines the row address to be cycled.

2. RINT, generated by the microprocessor, enables refreshing of one row address.

2B-51. The refresh controller uses these signals within the Row/Column Decoder circuits to cycle through all 128 row addresses every 2 ms. Because the Byte/Bank Decoder generates all the row address strobes simultaneously, each time the COUNT signal is active, both banks in the Main Memory are refreshed at the same time. Note that the RAM IC's receive only the row address strobes. Therefore, they only perform a refresh operation and not a read or a write operation.

2B-52. BYTE PARITY

2B-53. The Parity Generator/Checker performs two functions: Write Parity Generation, Read Parity Checking. These two functions are part of an error check/detection scheme that uses an extra (ninth) bit for each byte. Both functions are described in detail in the following paragraphs.

2B-54. Write Parity Generation

2B-55. To generate parity bits for each byte on a write operation, the Parity Generator/Checker looks at the 16-bit word on the Data Input Bus and treats it as two 8-bit bytes. At this point in time, each byte is treated as if it had 9 bits and the ninth bit (the parity bit) is a 0. It analyzes the lower (even) byte and causes a parity output bit to be set to either a one or zero, as necessary, to maintain an odd number of 1 bits in the byte. At the same time, it analyzes the upper (odd) byte and sets the other parity output to maintain an odd number of 1 bits in that byte. These two parity output bits, DNEP and DNOP (Data In Even Parity and Data In Odd Parity) make up an input to the Main Memory which treats them as part of the data word and stores them along with each byte.

2B-56. Read Parity Checking

2B-57. To check the parity of each byte during a read operation, the Parity Generator/Checker checks the number of 1 bits in each byte (including the parity bit) of the word and produces a Hardware Error signal (HERR) if the correct parity is not found. Note that the two parity bits DOEP and DOOP (Data Out Even Parity and Data Out Odd Parity) are not part of the Data Output Bus and, therefore, do not leave the Memory Module.

2B-58. SWITCH SELECTABLE BANKS

2B-59. The four switches (S1 S2 S3 S4) on the Byte/Bank Decoder establish the board number. However, the 1720A uses only one memory board. S1 and S2 are always on.

Section 2C
IEEE-488 Interface Module

2C-1. INTRODUCTION

2C-2. This section consists of two parts. The first part is an introduction to the IEEE-488 Bus. This part may be skipped if an introduction is not needed. The second part is the actual theory of operation for the IEEE-488 Interface Module. This module provides the two independent IEEE-488 ports that allow the 1720A to be an instrument controller. There can be 15 instruments, including the 1720A, on each port.

2C-3. INTRODUCTION TO THE IEEE-488 BUS

2C-4. The various terms and concepts used in the IEEE Standard 488-1978 entitled "IEEE Standard Digital Interface for Programmable Instrumentation" are described in the following order:

1. Basic Concepts and Terms
2. Bus Operating Modes
3. Three Wire Handshake
4. Operational Sequences

2C-5. Basic Concepts and Terms

2C-6. The IEEE-488 Bus consists of 16 signal lines. All signals on these lines are TTL level, low-true digital logic. Specifically:

1. True is a low level, 0 to 0.8V and is a logic 1.
2. False is a high level, 2 to 5V and is a logic 0.

2C-7. This discussion uses the above definitions in a particular convention. References within text use the terms true and false. Diagrams with waveforms indicate low and high levels. Charts or tables use 0 and 1 or low and high.

2C-8. Bus devices may have a variety of internal functions, and several types of communication capability. However, each must have at least a talker, a listener, or a controller interface capability. Each capability is defined as follows:

1. A Talker is a source of data going to other devices. For example, a voltmeter is talking when it sends measurement results orstatus information to the controller. Only one talker may be active at a time. There are two ways a device may talk. Either an operator switches a device to talk only which causes it to talk all the time, or the controller commands the device to talk.

2. A Listener is an acceptor of data from other devices. For example, a printer is a listener when it receives measurement results from a voltmeter to be printed. Up to 14 devices may listen simultaneously. There are two ways a device may become a listener. Either an operator switches the device to listen-only which causes it to listen all the time, or the Controller commands the device to listen.

3. A Controller manages bus communications. It has the power to designate the talker and listeners on the bus. The 1720A is a System Controller and has the capabilities listed below:

   a. Command devices to listen, talk, or perform their functions.

   b. Trigger devices to perform a pre-programmed function.

   c. Clear devices to an initial state (defined by the device).

d. Poll devices for their status serially (one device at a time).

e. Poll devices for their status in parallel (all devices at once).

f. Command devices to abort current operations.

g. Command devices to enter the remote mode of operation.

2C-9. The devices that are talkers and listeners on the IEEE-488 Bus usually have address switches. The operator sets these switches to the lower 5 bits of the preferred listen/talk address of the device. Refer to the Command Mode discussion and Table 2C-4 under Address Commands for a complete explanation of how the Controller makes use of this address.

2C-10. In addition to having talk, listen, and/or control capabilities, the bus devices can have various additional interface function capabilities designed into them. Table 2C-1 lists all IEEE Interface functions and their symbols. Note that the Controller abilities listed earlier need matching abilities in the bus devices if the Controller ability is to be implemented for a given device.

Table 2C-1. IEEE Interface Function Repertoire

INTERFACE FUNCTION	SYMBOL
Source Handshake	SH
Acceptor Handshake	AH
Talker or Extended Talker	T or TE
Listener or Extended Listener	L or LE
Service Request	SR
Remote Local	RL
Parallel Poll	PP
Device Clear	DC
Device Trigger	DT
Controller	C

2C-11. The 16 IEEE Bus lines fall into three categories. The signals within each category are defined in Table 2C-2. These categories are:

1. Eight data lines.

2. Three handshake lines

3. Five bus management lines.

2C-12. Figure 2C-1 presents a block diagram of bus device connections. The 1720A is connected to the IEEE Bus in the same way as the devices it controls. This reduces the number of device positions from 15 to 14.

2C-13. Bus Operating Modes

2C-14. INTRODUCTION

2C-15. The bus operates in either the command mode or the data mode during the transfer of data from one device to another. A controller uses the command mode to control the various devices on the bus with interface dependent commands. A talker or a controller uses the data mode to transfer data or device dependent commands on the DIOx lines. The three handshake signals mentioned previously officiate transfers on the bus. The handshake portion of this discussion covers this in detail later on.

2C-16. COMMAND MODE

2C-17. A controller places the system into Command Mode by bringing the ATN- line true (low). While ATN- is true, all devices on the bus must interpret the data byte as a command message. Only a controller may issue commands, and the IEEE-488 Standard defines all available command messages. Table 2C-3 defines four categories of command messages. Table 2C-4 defines the command messages within these categories. The codes for the various addresses and command groups fall into numerical groupings. The actual codes and addresses in ASCII, hexadecimal, octal, decimal, and binary appear in the Programming Manual.

2C-18. DATA MODE

2C-19. The controller places the system into the data mode by setting the ATN– line false (high). While ATN is false, all devices on the bus treat the data byte as data. This data can originate from either the talker or the controller. The data that flows from device to device on the bus (talker to listener) can be in any mutually understood code or format. The 1720A can act as an interpreter, accepting data from a talker and sending it out to a listener. This is covered in detail under Operational Sequences.

2C-20. Three-Wire Handshake

2C-21. All source and accepter bus devices use a three-wire handshake to exchange data bytes. Typically, the source is a talker and the acceptor is a listener. Figure 2C-2 is a flowchart of the handshake process which actually shows two flows, one for the source role and one for the acceptor role. The dotted lines crossing between these two flows show both the direction of the signal and the meaning of the level (high or low) the signal has at that particular time. The circled numbers inside some of the flowchart blocks refer to the level changes shown in the handshake signal line timing sequence, Figure 2C-3.

Table 2C-2. IEEE Bus Signal Lines

CATEGORY	NAME	DEFINITION	FUNCTION
1	DIO 1- DIO 8-	Data Input/ Output 1 through 8	Data, address, or command, in bit-parallel, byte-serial format. Information transfer is asynchronous and bidirectional.
2	DAV-	Data Valid	Low from source to indicate valid data on the DIOx lines. Source won't change data until NDAC- goes high. High from source to acknowledge that NDAC- went high and data is no longer valid.
	NRFD-	Not ready For Data	Wired OR output from all acceptors. Low indicates that one or more acceptors acknowledge that valid data is on the DIOx lines and that they are proceeding to read it. High indicates that all acceptors are ready for more data.
	NDAC-	Not Data accepted	Wired OR output from all acceptors. Refer to Figure 2C-2 (Handshake Flowchart) for full explanation of low state. Low, during the handshake, indicates one or more acceptors are in the process of reading the data and the source must not change it. High indicates that all acceptors have accepted the data and the source may change the data. Low, at the end of the handshake, indicates that all acceptors have acknowledged DAV- going high.
3	ATN	Attention	Low set by Controller to indicate DIOx lines carry addresses or commands from the Controller. High set by Controller to indicate that DIOx lines carry data from talker or Controller.
	IFC	Interface Clear	Pulsed low by Controller to place talkers and listeners into device determined idle state (neither talker nor listener).
	SRQ-	Service Request	Low sent by any capable device to the Controller to indicate a need for service.
	REN	Remote Enable	Low set by Controller to a listener to disable local control and allow the Controller to program the device.
	EOI	End or Identify	Low from talker to indicate end of mutiple byte data transfer (ATN- set high). Low from the Controller to indicate a parallel poll sequence (ATN- set low).

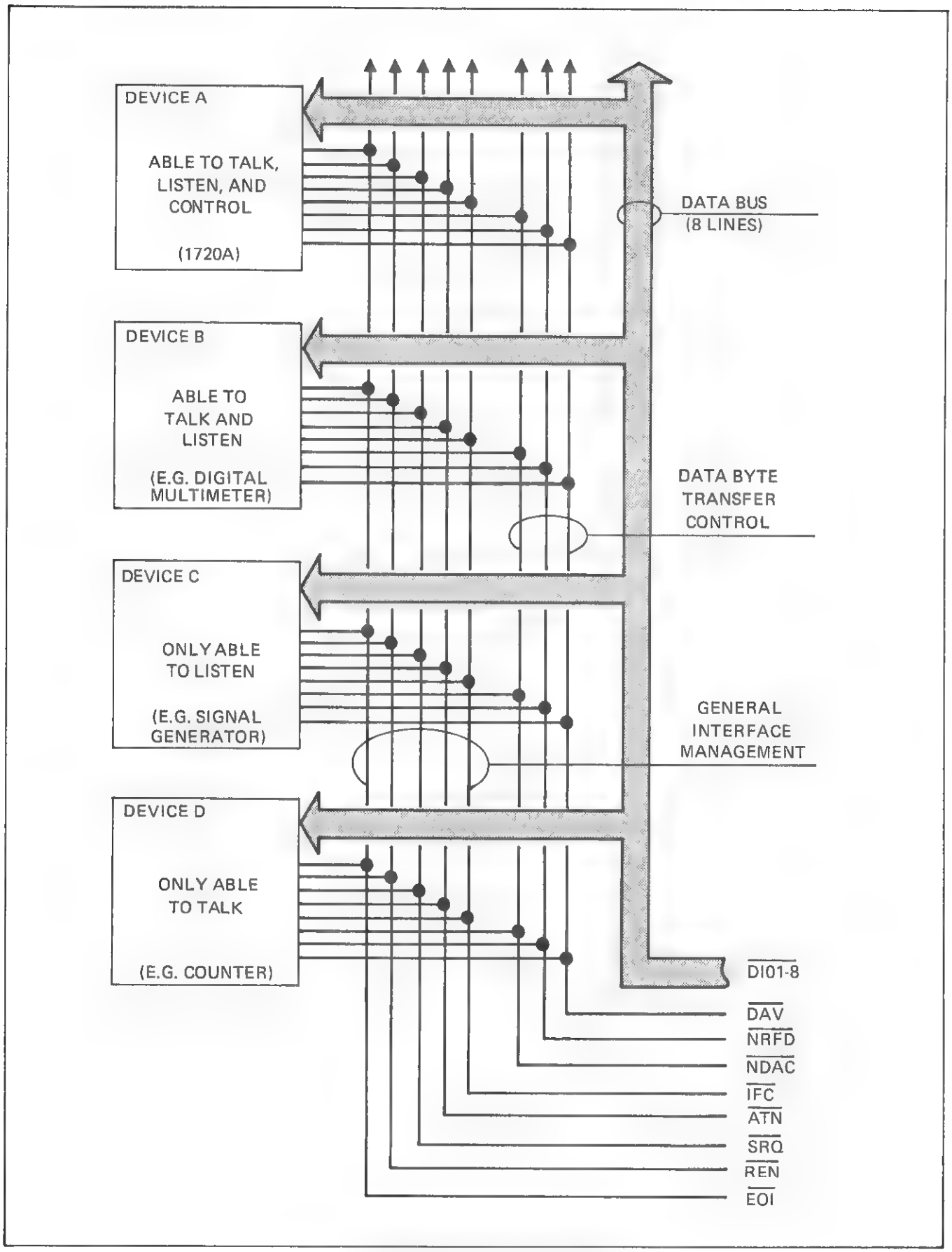


Figure 2C-1. IEEE Bus Connections

Table 2C-3. Command Message Categories

CATEGORY	DEFINITION
Primary Addressed Commands	Provide a contoller with the capability to control a selected group of devices. Since only those devices previously addressed to listen must respond to an addressed command, the command must be preceeded by the device address.
Universal Commands	Provide a controller with the capability to control all system devices. Since all devices must respond to a universal command (if capable), the command does not need to be preceeded by a device address.
Primary Address Command	Provide a controller with the capability to designate a device to function as a talker (source) or listener (acceptor).
Secondary Commands	Provide a controller with the capability to implement the extended talk or listen capabilities of a device, as well as the means to conduct a system parallel poll. A secondary command is the second byte of a two byte command.

2C-22. Operational Sequences

2C-23. Figure 2C-4 shows two possible minimum system configurations. One possible operational sequence, by a controller, for each of these systems is given in the following paragraphs.

2C-24. SYSTEM CONFIGURATION #1

1. The Controller initializes the interface devices by setting the IFC and REN lines true on each bus.

2. The Controller sends the listen address (MLA) of the voltmeter followed by the program data for the voltmeter on Bus #0.

3. The Controller sends the unlisten command (UNL) on Bus #0.

4. The Controller waits for an operator input or some other event defined by the user program.

5. The Controller sends the listen address (MLA) of the voltmeter, followed by the program code required or a GET (Group Execute Trigger) to initiate a measurement on Bus #0.

6. The Controller sends the unlisten command (UNL) on Bus #0, then proceedes to go on to other tasks as demanded by the user program.

7. Upon completion of its measurement, the voltmeter set the SRQ– line true.

8. The Controller sends the talk address (MTA) of the voltmeter on Bus #0, then uses the three-wire handshake to get the data bytes representing the voltmeters measurement.

9. The Controller sends the untalk command (UNT) on Bus #0.

10. The Controller processes the data, formats it, or does whatever the user program dictates.

11. The Controller sends the listen address (MLA) of the printer on Bus #1.

12. The Controller sends the processed data to the printer on Bus 1, using the three-wire handshake.

13. The Controller sends the unlisten command (UNL) on Bus #1.

2C-25. SYSTEM CONFIGURATION #2

1. The Controller initializes Bus #0 by setting the IFC and REN lines true.

2. The Controller sends the listen address of the voltmeter (MLA), followed by the program data for the voltmeter.

3. The Controller sends the unlisten command (UNL) on Bus #1.

4. The Controller waits for an operator input or some other event defined by the user program, then sends the listen address command (MLA) to the voltmeter, followed by the code that initiates the voltmeters reading on Bus #0.

5. The Controller sends the unlisten command (UNL) on Bus #0.

6. The Voltmeter makes its measurement and sets the SRQ– line true.

7. The Controller sends the listen address (MLA) of the printer and the talker address (MTA) of voltmeter.

8. The voltmeter uses the three-wire handshake to send the byte of data representing its measurement to the printer. This byte must be in a mutually understood code.

9. The Controller sends the unlisten (UNL) and untalk (UNT) commands on the bus.

CATAGORY	MNEMONIC	MESSAGE NAME	MANAGEMENT SIGNALS	INTERFACE FUNCTIONS REQUIRED TO: SEND	INTERFACE FUNCTIONS REQUIRED TO: RECEIVE	DEVICE RESPONSE
Primary Addressed Commands	GTL	Go To Local	ATN	C	RL	Device returns from remote to local mode of operation.
	SDC	Selected Device Clear	ATN	C	DC	Device configures to a pre-defined state defined by device manufactor.
	PPC	Parallel Poll	ATN	C	PP	Device Becomes addressed to configure so that if the next command is a PPE (Parallel Poll Enable) the device becomes configured to respond with a status bit when the controller initiates a parallel poll (EPI and ATN set) another next command reverts the device to be unconfigured.
	GET	Group Execute Trigger	ATN	C	DT	Initiates a device function among a selected (addressed) group of devices.
	TCT	Take Control	ATN	C	C	Device previously addressed to talk assumes Controller-In-Charge function and previous Controller-In-Charge becomes idle.
Universal Commands	LLO	Local LockOut	ATN, REN	C	RL	Disables Device Local controls so that devices can not prevent REN from putting devices in Remote Mode.
	DCL	Device ATN	ATN	C	DC	Devices configure to conditions pre-defined by their manufactors.
	PPU	Parallel Poll Unconfigure	ATN	C	PP	Devices return to the Parallel Poll unconfigured condition (no logic level or DIO line assigned for status bit response to Parallel Poll). If next command is PPE, device will reconfigure for Parallel Poll.
	SPE	Serial Poll	ATN	C	T, TE	Devices enter serial poll mode so that a subsequent talk command (MTA) will cause the device to write its status byte (see STB, RQS) on the DIO lines when the bus enters the data mode.
	SPD	Serial Poll Disable	ATN	C	T, TE	Devices exit serial poll mode and can no longer talk a status byte onto the DIO lines.
Primary Address Commands	MLA	My Listen Address	ATN	C	L, LE, RL, T	Device becomes addressed to listen if DIO 1-5 equals internal address switch setting unless a secondary address (MSA) is required. Device also enters Remote Mode if TEN is set. Device with capability will unaddress itself to talk. 31 addresses are available.
	UNL	UNListen	ATN	C	L, LE	Device becomes unaddressed to listen.

CATAGORY	MNEMONIC	MESSAGE NAME	MANAGEMENT SIGNALS	INTERFACE FUNTIONS REQUIRED TO:		DEVICE RESPONSE
				SEND	RECIEVE	
Primary Address Commands (cont)	MTA	My Talk Address	ATN	C	T, TE L	Device becomes addressed to talk if DIO 1-5 equals internal address switch settings unless a secondary address (MSA) is required. Device with capability will unaddress itself to listen. 31 addresses are available
	OTA	Other Talk Address	ATN	C	T, TE	Devices become unaddressed to talk if any MTA other than their own is on DIO 1-5
	UNT	UNTalk	ATN	C		Devices become unaddressed to talk.
	MSA	My Secondary Address	ATN	C	TE, LE	Device with extended talker capability becomes unaddressed to talk if first talk address byte (MTA) equaled its address switch settings but this byte does not.
	OSA	Other Secondary Address	ATN	C	RE	Device which was prviously parallel poll configured by PPE command becomes unconfigured (no longer has status bit logic level and DIO line assigned). If the next command is PPE, the device will become reconfigured. This command must be preceded by the PPC command.
	PPD	Parallel Poll Disable	ATN	C	TE	Assigns a device a status bit logic level (high or low) and a DIO line to put the status on when IDY occurs (ATN and EOI concurrently). This command must be preceded by the PPC command.
	PPE	Parallel Poll Enable	ATN	C	PP	DIO Response Line # / Octal Code on Bus (if status bit is on) High / Low 1: 140 / 150 2: 141 / 151 3: 142 / 152 4: 143 / 153 5: 144 / 154 6: 145 / 155 7: 146 / 156 8: 147 / 157
Device Dependent	DAB	DAta Byte		T, TE	L, LE	Any byte on the DIO lines transferred between a source and one or more acceptors may represent program code, device status or measurement results.

Table 2C-4. Command Bus Messages (cont)

CATAGORY	MNEMONIC	MESSAGE NAME	MANAGEMENT SIGNALS	INTERFACE FUNTIONS REQUIRED TO:		DEVICE RESPONSE
				SEND	RECIEVE	
Device Dependent (cont)	EOS	End Os String		T, TE	L, LE	A source can write Line feed or Carrage Return or both in sequence on the DIO lines to provide printer control as well as to acknowledge the end of a string of data byte transfers.
	NUL	Null Byte		T, TE		Source writes zeros onto DIO 1-8 to initialize the bus.
	PPR 1-8	Parallel Poll Response		PP	C	Device status bit response on DIO line and of logic level assigned by PPE Command. This is the only data which is transferred without the 3-wire handshake.
	STB	Status Byte		T, TE	L, LE	Device reponse to serial poll STB is concurrent with ROS. Status Bits are on DIO 1-5
	RQS	Request		T, TE	L, LE	Device response to serial poll STB if device requested service by setting SRQ. RQS is concurrent with STB and consisters of DIO 7 being set. SRQ is cleared provided the condition causing it no longer exists.

Table 2C-4. Command Bus Messages (cont)

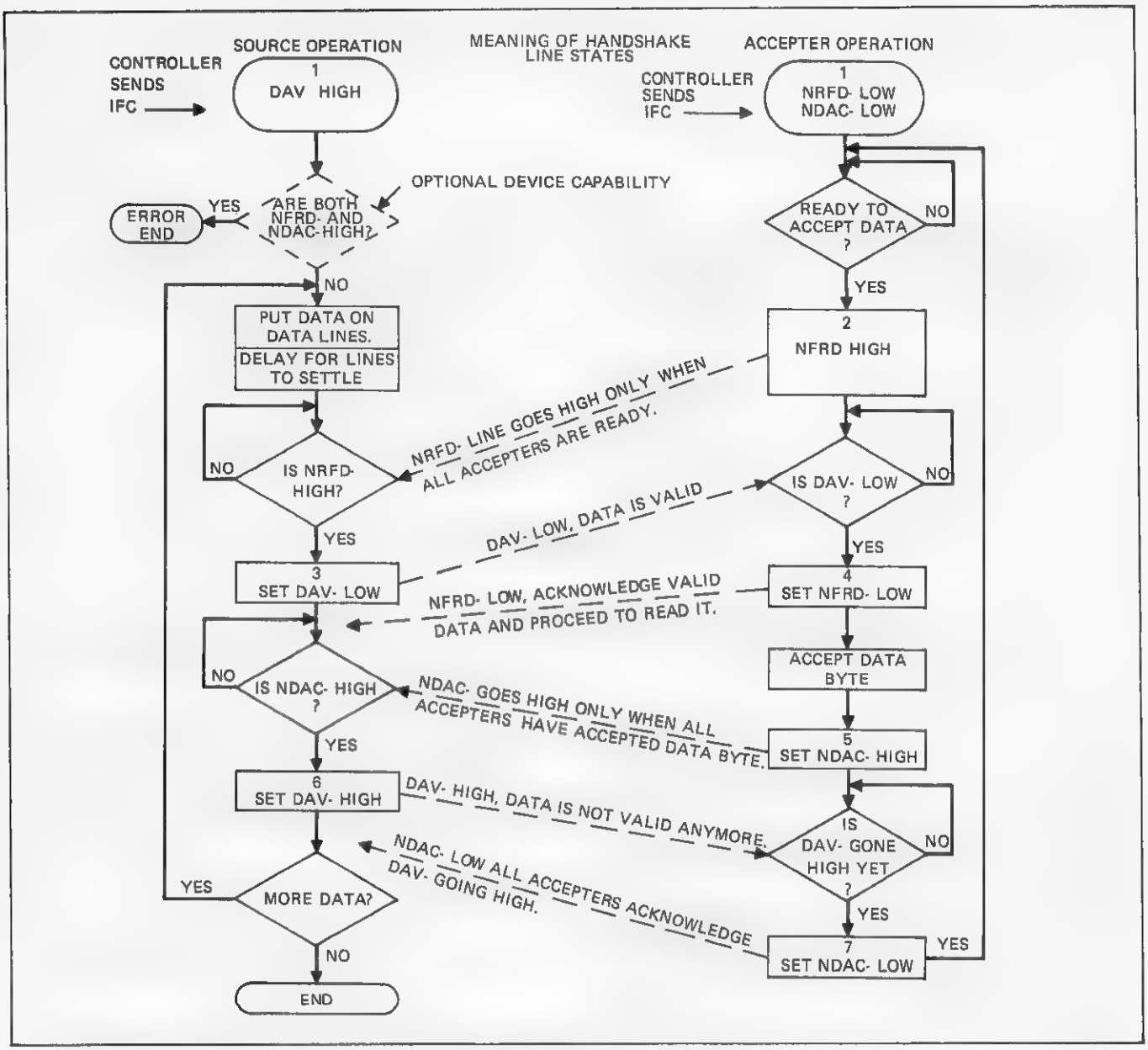


Figure 2C-2. Handshake Flowchart

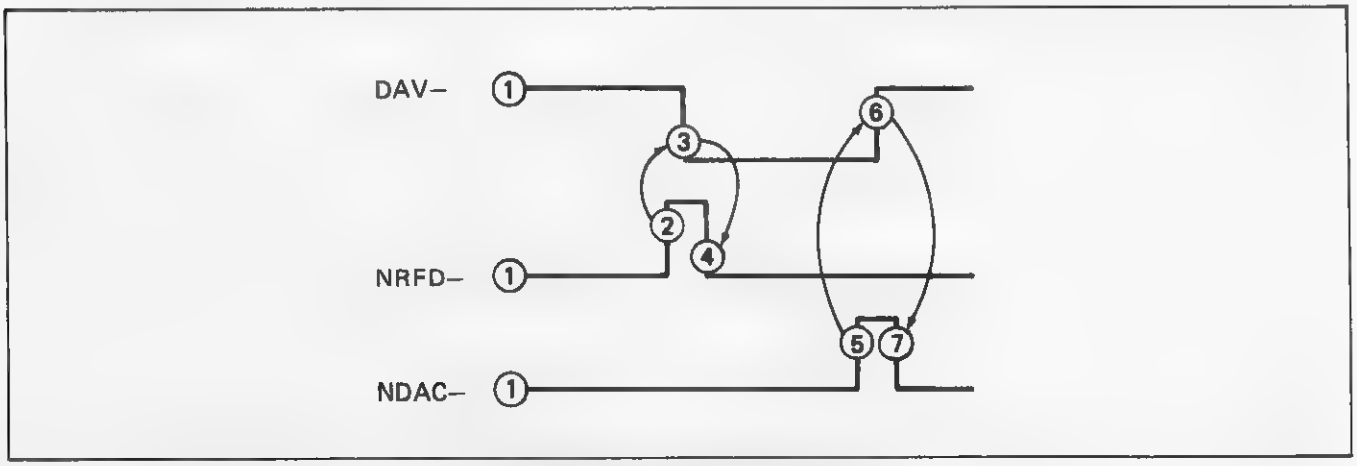


Figure 2C-3. Handshake Timing

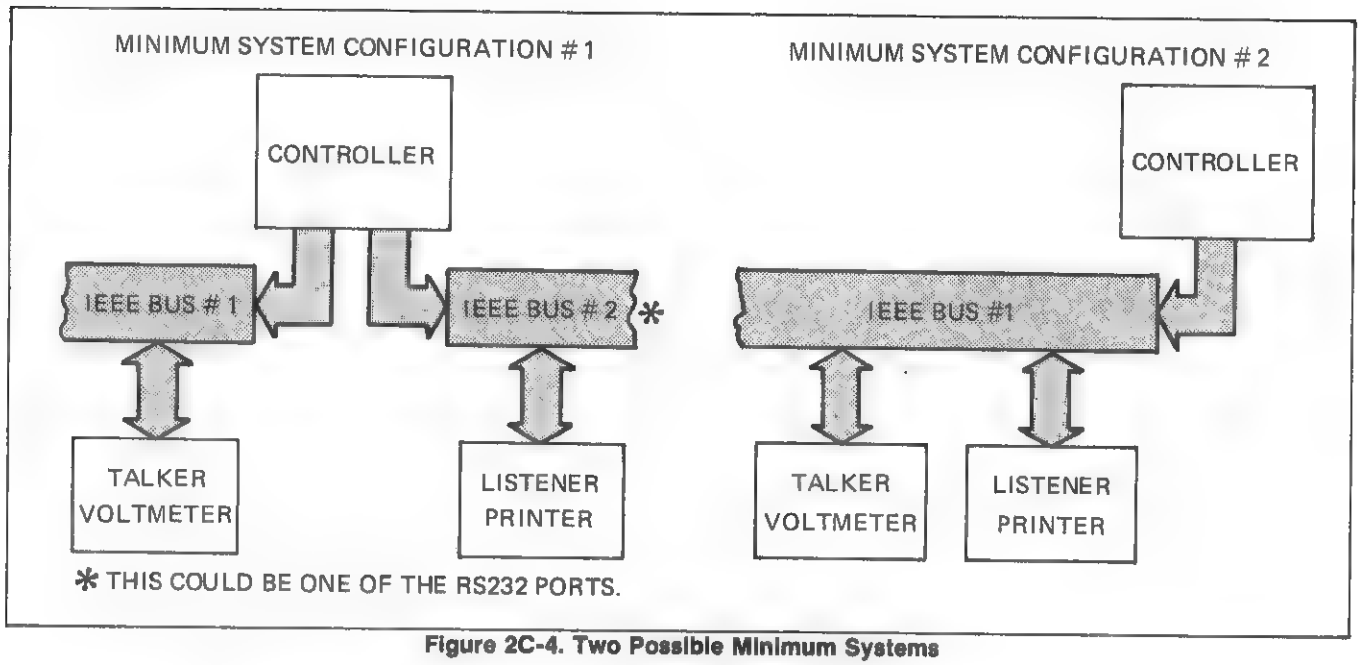


Figure 2C-4. Two Possible Minimum Systems

2C-26. IEEE-488 INTERFACE MODULE THEORY OF OPERATION

2C-27. Introduction

2C-28. The IEEE-488 Interface Module allows the 1720A Controller to communicate with two IEEE-488 buses. This allows the user to increase system throughput by configuring the system with fast instruments on one bus and slow instruments on the other. Since each bus has a capacity of 15 instruments, the 1720A can directly control 28 other devices. Each IEEE-488 Bus has the ability to act as non-system controller and to pass control (with appropriate software, not presently available) and to implement most of the interface functions within the IEEE Standard 488-1978, including all controller functions.

2C-29. In addition, selectable interrupt driven bus communications can free the 1720A for other tasks during slow bus transfers. Also, each bus interface has readback circuitry to talk to itself and, thus, diagnose the operation of the hardware via a self-test routine.

2C-30. Two Independent IEEE-488 Ports

2C-31. Refer to the IEEE-488 Module Block Diagram in Figure 2C-5 and note that the two IEEE-488 Ports have many functional blocks in common. The two ports become functionally separate from the point at which the Data and Control Registers are implemented. From that point on, there are registers and functional blocks that are duplicated in each port. One important point that may not be obvious is that the output from the Data/Control Register goes to two places. The Data portion goes directly to the Port Drivers and the Control portion goes to the Handshake Control.

2C-32. With two exceptions (see Automatic IFC and Automatic DCL) the CPU Module uses software control, via the CRU Bus, to accomplish all IEEE Bus data transfers through the registers. For the purposes of this software control, there are four registers:

1. Reg. 1 Port 1, Data/Control (16 bits)
2. Reg. 2 Port 0, Data/Control (16 bits)
3. Reg. 3 Port 1, Status/Control (8 bits)
4. Reg. 4 Port 0, Status/Control (8 bits)

2C-33. The CPU Module can set (write) each bit in these registers by using the CROUT and CRCLK lines, or it can sense (read) each bit by using the CRIN line. This gives each bit in these registers two meanings, one for the output from the CPU to the IEEE Module (write), and one for the input to the CPU from the IEEE Module (read). To provide this capacity, there is actually a pair of hardware registers in the IEEE Interface Module for each software register. Each pair of hardware registers appears as one software register because each CRU bit address actually accesses the same bit in twodifferent hardware registers. When the software does a write (CROUT) it accesses the bit in one register, and when it does a read (CRIN), it accesses the bit in the other register.

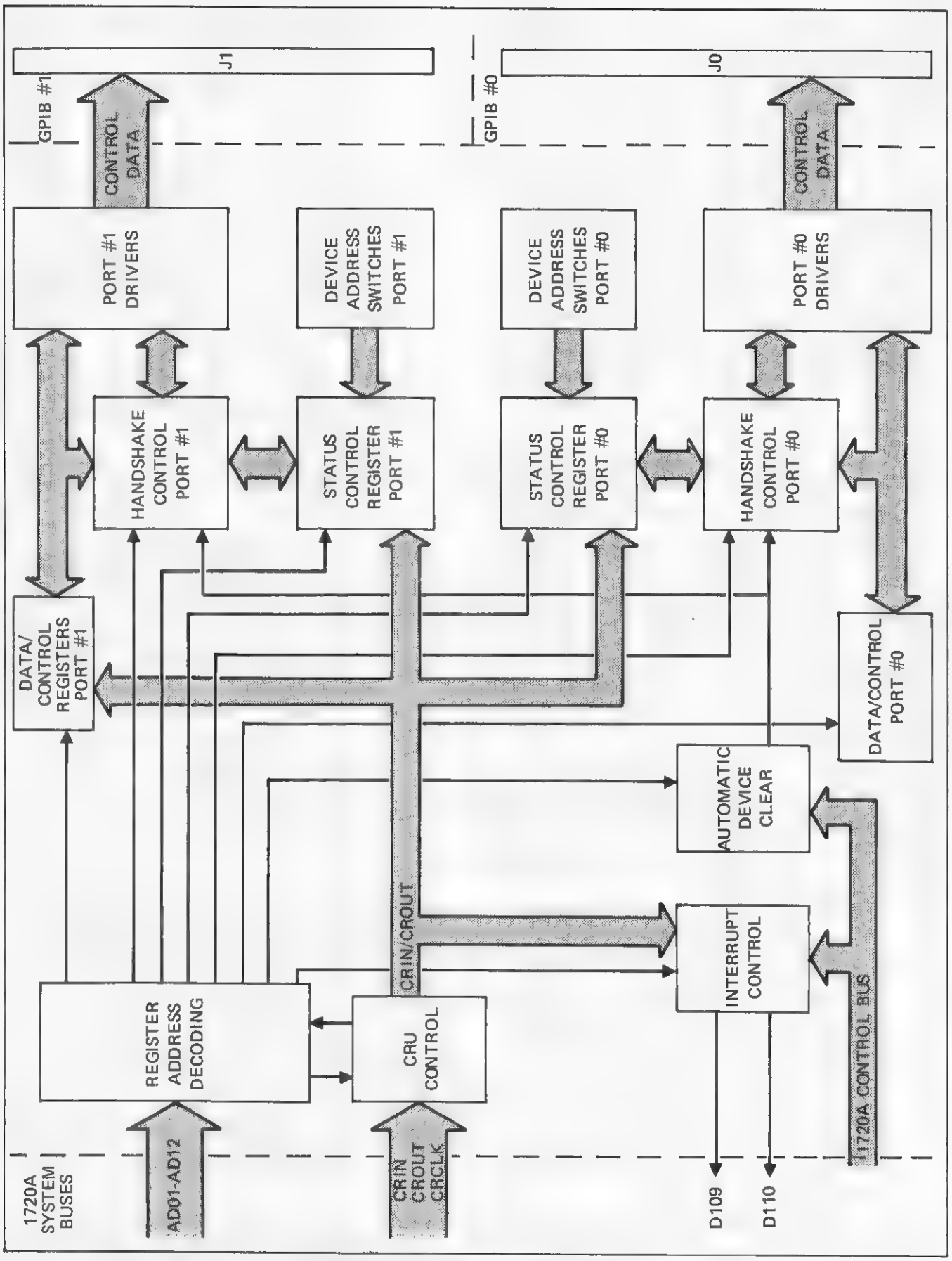


Figure 2C-5. IEEE Module Block Diagram

2C-34. The CPU Module addresses each bit in these registers with a separate CRU address. This address appears on the 1720A Address Bus bits AD01 through AD12. The Register Address Decoding on the IEEE Interface Module recognizes that the address is for one of the bits in one of the IEEE Interface registers and proceeds to decode AD04 through AD06 into one of six pairs of strobe/enable signals. One signal from this pair acts as a strobe to a 8-bit register that contains the bit that is accessed by the CROUT line (write) and is only active if the address is accompanied by CRCLK. The other signal from the pair acts as an enable to a 8-bit register that is accessed by the CRIN line (read). Table 2C-5 contains the IEEE Interface register address decoding and presents the above relationship in tabular form. The Chip # referred to in Table 2C-5 is the unit number of the 8-bit register on the IEEE-488 Interface Module schematic. The register number is the software register number referred to previously.

2C-35. Each 8-bit register that is strobed or enabled decodes Address Bus bits AD01, AD02 and AD03 into a bit number within the register. As stated previously, this bit can have two meanings, one for output to the CPU (read), and one for input from the CPU (write). Table 2C-5 shows this relationship in tabular form by giving the bit name for the write and read bits. These bit names are mnemonics which correspond with the IEEE Bus signals in some cases. In those cases where they do not, they reflect the function they have within the IEEE Interface Module. The following paragraphs use these mnemonics and give the full signal names which state the internal function of the signal.

2C-36. In summary, each IEEE-488 Interface circuit consists of a talker circuit and a listener circuit which complete the source handshake (SHS) and the acceptor handshake (AHS), respectively. Control and status bits in four registers dictate the operation of these handshakes, and the data bits control the data being exchanged. The CPU accesses these four registers via the CRU bus.

2C-37. IEEE Bus Read Operation

2C-38. The description that follows covers Port #1. The operation of Port #0 is the same. To read a byte of data from the IEEE Bus the software controlling the CPU goes through the following, or similar, steps:

1. Set LTN (Listen) or LA (Listen Always) to a 1. Setting the LA bit (Registers 3 and 4, bit 7) forces the associated IEEE Interface Port to listen to itself as well as other devices (sources) and respond accordingly. Two things happen:

   a. NRFD - on the IEEE bus goes false (high).

   b. The RDY interrupt is enabled if the RDY mask bit =1.

2. The RDY bit which goes to a 1 when DAV- on the IEEE Bus goes true (low).

   a. This can be done by a repetitive read of register 1 bit 11.

   b. This can be done with an RDY interrupt followed by a read of register 1 (if the RDY Mask bit is =1 to allow the interrupt to occur).

3. Read the incoming data byte from Register 1 when RDY goes to a 1. If the data byte is not the last byte (no terminating character or no EOI), then toggle ACC (set high, then low) and repeat the process (go back to step 1).

4. If the data byte is the last character, the user software may choose to hold NRFD on the IEEE Bus true (low, the bus is not ready) until the handshake is finished. To do this, the software:

   a. Sets RHO (Ready Hold Off) to a 1 to hold NRFD- true.

   b. Toggles ACC to assert NDAC- high (data accepted) and complete the handshake. The Handshake Control will set NDAC- low again.

   c. Tests HDN (Handshake Done) until true (= 1). This occurs when the current talker on the IEEE Bus puts DAV- high at the end of the handshake.

   d. Sets ATN in Register 1 to a 1 to make ATN- on the IEEE Bus true (low).

   e. Sets RHO to a 0 to set NFRD- false (high) on the IEEE Bus.

2C-39. Step 4 in the previous sequence is sometimes necessary to prevent some instruments from placing a new (and sometimes undefined) data byte on the bus and having it lost when the controller asserts ATN.

2C-40. IEEE Bus Write Operations

2C-41. To write a byte of data on the IEEE Bus the software controlling the CPU must go through the following, or similar, steps:

1. Set LTN to 0 to release control of the two listen handshake lines, NRFD- and NDAC-, and take control of the talker handshake line from the talker DAV-.

2. Write the data byte into register 1 bits 0 through 7 to place the data byte onto the DI01 through DI08 lines on the IEEE Bus.

Table 2C-5. IEEE Interface Register Address Decoding

REG. NAME	CHIP #	STROBE/ ENABLE	BIT #	ADDRESS BUS 6 5 4 3 2 1	HEX ADD	REG. #	BIT NAME WRITE	BIT NAME READ
Data Port #1	U6, Write U13, Read	WDATA1 RDATA1	0 1 2 3 4 5 6 7	0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 1 0 0 0 0 1 1 1	000 001 002 003 004 005 006 007	1	D101 D102 D103 D104 D105 D106 D107 D108	D1I1 D1I2 D1I3 D1I4 D1I5 D1I6 D1I7 D1I8
Control Port #1	U5, Write U12, Read	WCNT1 RCNT1	8 9 10 11 12 13 14 15	0 0 1 0 0 0 0 0 1 0 0 1 0 0 1 0 1 0 0 0 1 0 1 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 1 1 1 0 0 0 1 1 1 1	008 009 00A 00B 00C 00D 00E 00F		EOI1 RHO1· LTN1 ACC1 NBA1 IFC1 REN1 ATN1	EOI1R- SRQR1 HDN1- RDY1 DUN1 NLR1- RENR1- ATNR1
Data Port #0	U62, Write U55, Read	WDATA0 RDATA0	0 1 2 3 4 5 6 7	0 1 0 0 0 0 0 1 0 0 0 1 0 1 0 0 1 0 0 1 0 0 1 1 0 1 0 1 0 0 0 1 0 1 0 1 0 1 0 1 1 0 0 1 0 1 1 1	010 011 012 013 014 015 016 017	2	D101 D102 D103 D104 D105 D106 D107 D108	D0I1 D0I2 D013 D0I4 D015 D016 D017 D0I8
Control Port #0	U61, Write U54, Read	WCNT0 RCNT0	8 9 10 11 12 13 14 15	0 1 1 0 0 0 0 1 1 0 0 1 0 1 1 0 1 0 0 1 1 0 1 1 0 1 1 1 0 0 0 1 1 1 0 1 0 1 1 1 1 0 0 1 1 1 1 1	018 019 01A 01B 01C 01D 01E 01F		EOI0 RH00 LTN0 ACC0 NBAD IFC0 RENO ATN0	E0IR0- SRQR0- HDN0- RDY0 DUNO NLR0- RENR0- ATNR0
Status/Control Port #1	U4, Write U2, Read	WGP1 RGP1	0 1 2 3 4 5 6 7	1 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 1 0 1 0 0 0 1 1 1 0 0 1 0 0 1 0 0 1 1 0 1 0 0 1 1 0 1 0 0 1 1 1	020 021 022 023 024 025 026 027	3	INTMSK1 DUNMSK1 RDYMSK1 SRQMDK1 CIC1 SRQOUT1 ATNMDK1 LA1	D1A0 D1A1 D1A2 D1A3 D1A4 SYNC1 INT1 IFCR1-
Status/Control Port #0	U60, Write U3, Read	WGP0 RGP0	0 1 2 3 4 5 6 7	1 1 0 0 0 0 1 1 0 0 0 1 1 1 0 0 1 0 1 1 0 0 1 1 1 0 0 1 0 0 1 1 0 1 0 1 1 1 0 1 1 0 1 1 0 1 1 1	030 031 032 033 034 035 036 037	4	INTMSK0 DUNMSK0 RDYMSK0 SRQMSK0 CIC0 SRQOUT0 ATNMSK0 LA0	D0A0 D0A1 D0A2 D0A3 D0A4 SYNC0 INTO IFCR0-

Note: Hex Add is for Board #0

3. As desired by the programmer, set EOI, ATN, REN, SRQ, or IFC at this time.

4. Toggle NBA (New Byte Available) high then low to make DAV– on the IEEE Bus go low, then high to signify a write operation. The Handshake Control block automatically controls the DAV– line levels to respond to NRFD– from the listeners. See Figure 2C-3 and 2C-4.

5. Test DUN until true (= 1).

a. This can be done by a continuous read of register 1.

b. This can be done by responding to a DUN interrupt with a read of register 1 (if the DUN Mask bit is =1 to allow the interrupt to occur).

DUN becomes true when all acceptors have taken the data byte (NDAC– goes high).

2C-42. Automatic IFC

2C-43. Both Ports send IFC (Interface Clear) upon power-up or power-fail if those ports have their SYC (System Controller) switch set. (Described later under Address Switch). The backplane signal DCOK signals power-up or power-fail to the IEEE Interface Module. Refer to the IEEE-488 Interface Schematics and follow the signal DCOK to U26 pin 10 in the Handshake Control Circuit. When DCOK goes low (DC not OK) the output at U26-8 goes high to enable one input to a NAND gate. The SYC bit enables the other input to this gate. As a result, IFC– goes true (low) on the IEEE Bus.

2C-44. Automatic DCL

2C-45. If the IEEE Bus interface circuits are configured as SYC (System Controller) and CIC (Controller In Charge) they will generate a DCL (Device Clear) on the IEEE Bus when certain backplane lines are true (note that CIC is bit 4 in registers 3 and 4). Refer to the Automatic Device Clear Block on both Figure 2C-5 and the Schematic. The backplane signals that cause DCL are:

1. HERR (Hardware Error), the result of a memory parity error detection.

2. ACOK (AC OK), a power warning from the power supply.

3. BCLR (Bus Clear), a CPY signal resulting from the execution of a RESET (RESET) instruction.

2C-46. Five Maskable Interrupts

2C-47. Refer to the Interrupt Control Block on both the Schematic and the Block Diagram, as this discussion proceeds. There are five interrupting sources available:

1. DUN - Occurs when all acceptors have taken data byte during a source handshake (NDAC– goes high)

2. RDY - Occurs when DAV– (Data Valid) on the IEEE Bus goes low (true) during an acceptor handshake.

3. SRQ - Occurs when SRQ– on the IEEE Bus goes low (true).

4. ATN - Occurs when ATN– on the IEEE Bus goes low (true).

5. IFC - Occurs when IFC– on the IEEE Bus goes low (true).

2C-48. Whenever one of these interrupts occurs, it sets the corresponding bit in registers 1 or 2 to a 1. These bits act as inputs to the Interrupt Control. Interrupt Control takes these inputs and ANDs them with the various MASK bits from Registers 3 and 4.

2C-49. The MASK bits in registers 3 and 4 can mask CUN, RDY, SRQ, and ATN individually or in any combination. The INT MASK bit masks all five interrupt sources at once and masks the IMT1 (Interrupt Board 1) or the INT2 (Interrupt Board 2) depending on which position the Board # Select Switch is in.

2C-50. The output of the Interrupt Control, INT1 or INT2, represents an ORing of all five interrupts. If any one of them occurs, and a corresponding mask bit is not set to a 0, INT1 or INT2 occurs. INT1 and INT2 are then ORed to produce the IEEE board interrupt to the processor. Hence, upon responding to an IEEE interrupt, the software must check to see if INT1 or INT2 is asserted.

2C-51. Configuration Switches

2C-52. Refer to the Dual IEEE-488 Module in Figure 2C-6. There are two configuration switches, one for Port 1 and one for Port 0. The individual switches are low true. Pushing a switch to an off position sets that position to a logical 1. Detail A on Figure 2C-6 shows a setting of 001001XX (X = don't care). This is equivalent to an address of 4 with SYC (System Controller) set to a 1.

2C-53. The software can read the setting of the address portion of these switches from registers 3 and 4 by reading bits 0 through 4. These bits are the DAx (Device Address) bits. The setting of the SYC bit can be read from bit 5 of registers 3 and 4. If desired, the programmer can use the device address as MTA (My Talk Address) for the Controller.

2C-54. Board # Select Switch

2C-55. Refer to the Dual IEEE-488 Module in Figure 2C-6. The Board # Select Switch serves two purposes within the IEEE Interface Module:

1. It changes the CRU address range that the registers occupy by making it necessary for AD07 to be set to a one if the switch is set to the Board #1 position and for AD07 to be set to a 0 if the switch is in the Board #0 position (AD01 through AD06 stay as in Table 2C-5).

2. It changes the Interrupt Control output to occur at DI10 if in Board #1 position and at DI09 if in Board #0 position. DI09 and DI010 are Data Input/Output lines that are low true to the Priority Interrupt circuit in the CPU during RINT cycles.

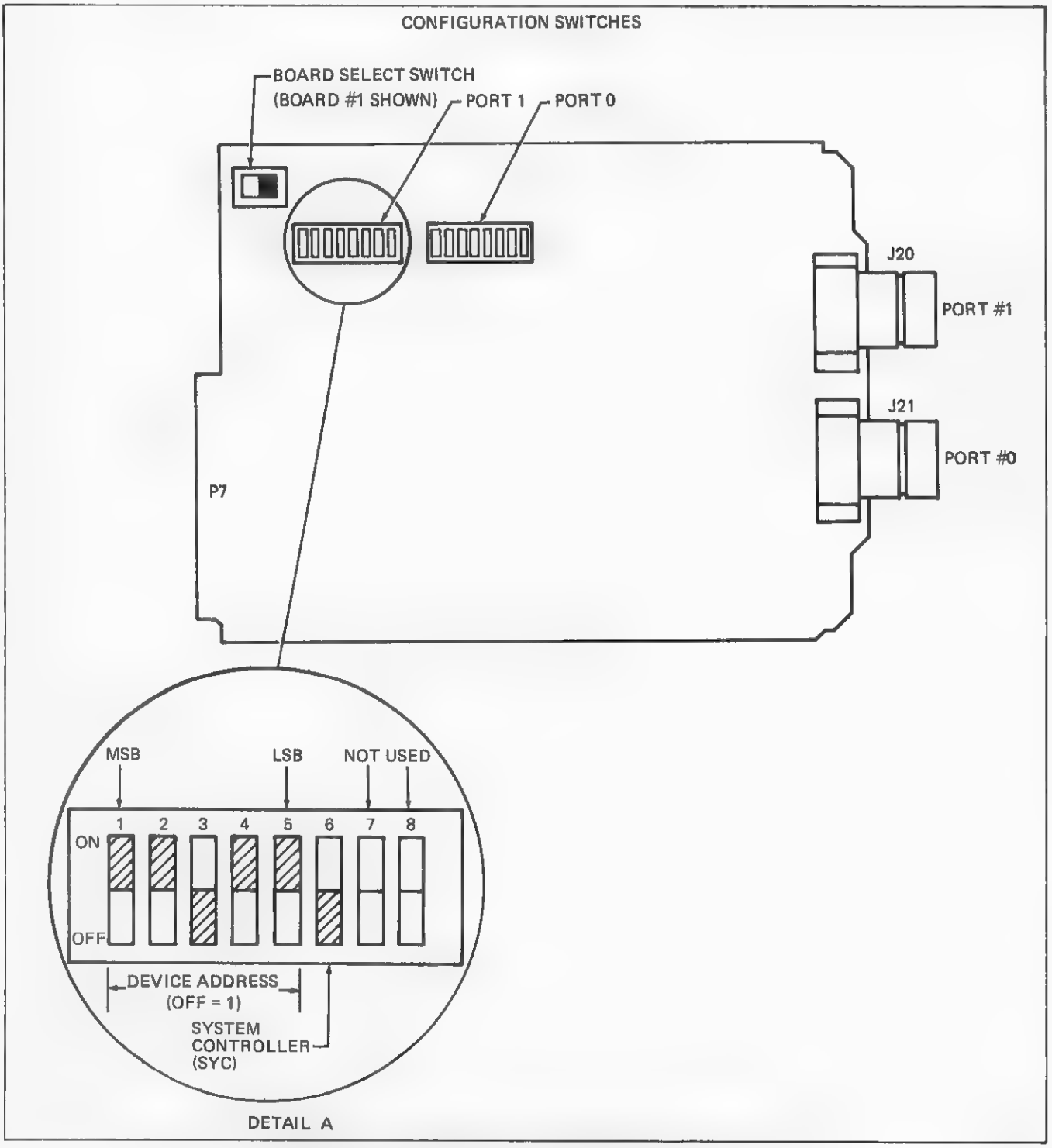


Figure 2C-6. Dual IEEE-488 Module Configuration Switches

Section 2D
Video/Keyboard Interface Module

2D-1. INTRODUCTION

2D-2. This Module performs three main functions within the 1720A Controller:

1. Receives display inputs from the CPU module, acknowledges their receipt, and stores them in a display memory.

2. Receives inputs from the Programmer Keyboard and the Touch-Sensitive Display then generates an interrupt to the CPU Module, and makes the information available to the CPU Module via the 1720A CRU Bus.

3. Generates the necessary outputs to enable the CRT Electronics to display the contents of the Display Memory.

2D-3. The module performs these functions with two major integrated circuit elements, a microprocessor and a CRT Controller. Figure 2D-1 shows the relationship between these two circuit elements and the other functional blocks in the module. The CRT Controller refreshes the CRT display via the video output and buffers the data from the display memory. The microprocessor interfaces the display memory to the 1720A System Buses and sets up the formatting of the CRT screen. It does this under the direction of a program that resides in ROM (Read Only Memory).

NOTE

This microprocessor and its CRU Bus, Address Bus, and Data Bus are separate and independent from the same components in the CPU Module. They do not leave the Video/Keyboard Module.

2D-4. FEATURES OF THE VIDEO/KEYBOARD MODULE

1. Four jumper-selectable cursor options:
   a. Blinking underline (standard)
   b. Blinking reverse video
   c. Non-blinking underline
   d. Non-blinking reverse video block
2. Two software selectable display formats:
   a. 16 lines of 80 characters (normal size characters)
   b. 8 lines of 40 characters (double size characters)
3. Software controlled keyboard lock
4. Four Special character modifiers:
   a. Highlight character(s)
   b. Blink character(s)
   c. Reverse video character(s)
   d. Underline character(s)
5. Eleven graphic symbols in double size.
6. Seven graphic symbols in normal size.
7. Characters are a 7 X 9 dot matrix set in a 8 X 14 cell.

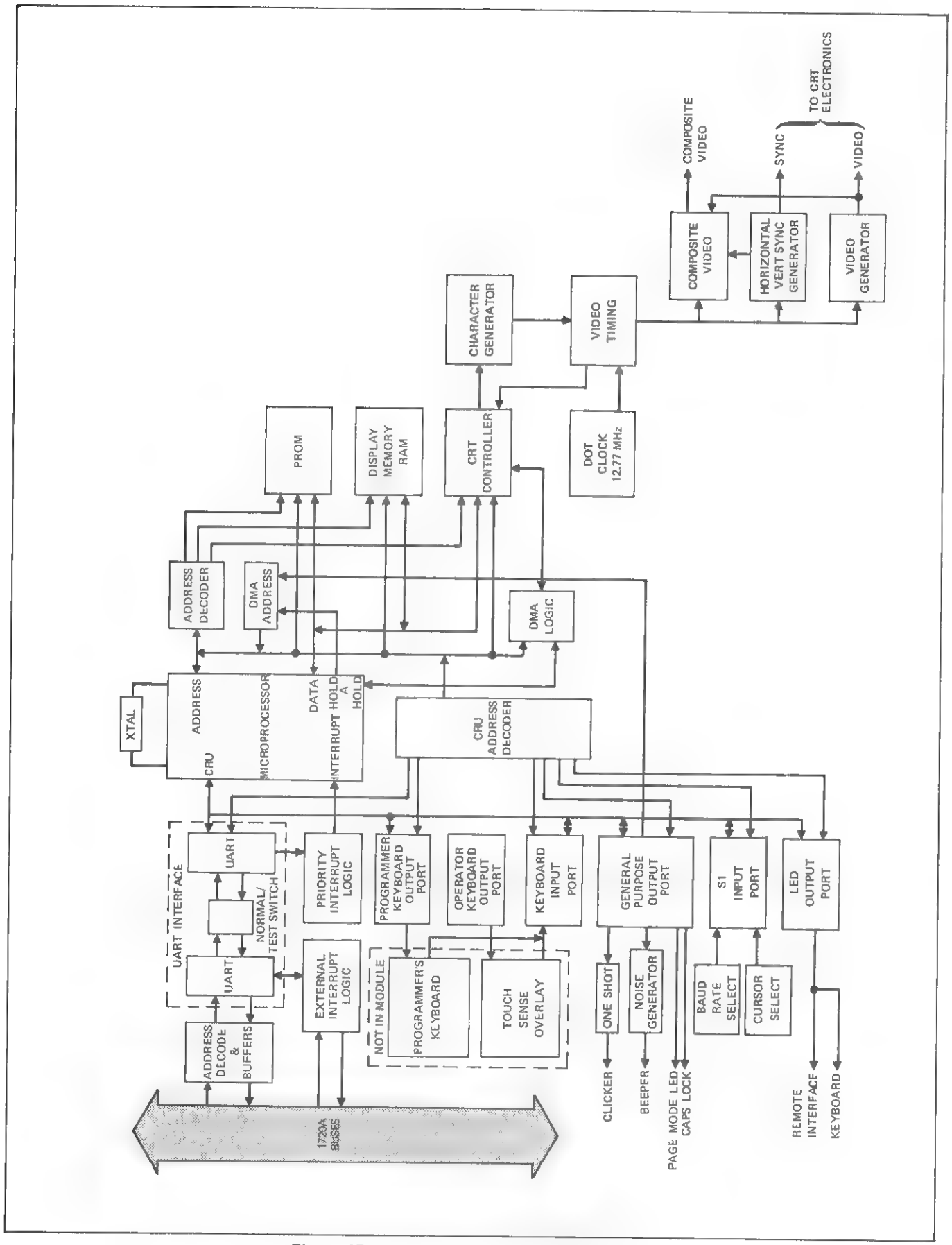


Figure 2D-1. Video/Keyboard Interface Block

2D-5. THE NORMAL/TEST SWITCH

2D-6. With S2 (NORMAL/TEST Switch) in the NORMAL position, the Video/Keyboard Module interfaces with the CPU Module via the 1720A CRU Bus. In general, the Video/Keyboard Module notifies the CPU Module when a keyboard entry on either the Programmer Keyboard or the Touch-Sensitive Display is made with an interrupt. The CPU Module then reads this character on its CRUIN line and, under software control, may display that character or take other action. If the CPU Module needs to display the character, it sends the character via the CRUOUT line to the Video/Keyboard Module for storage in a display memory and for display on the CRT. While S2 is in the NORMAL position, this is the only way characters can be displayed. This entire process is described in detail in the paragraphs that follow. Refer to the Test Mode Operation discussion for the differences in operation when S2 is in the TEST position.

2D-7. KEYBOARD SCANNING

2D-8. The microprocessor uses CRU lines to scan both the Programmer Keyboard and the Touch Sensitive Display through the Keyboard Output and Input Port. Figure 2D-1 shows this relationship. The difference between the CRU feature of this microprocessor and the CRU feature of the microprocessor in the CRU Module is that this microprocessor uses its LSB address line (VAD00) for its CRUPUT line instead of having a separate CROUT line. The CRUCIK and CRUIN lines function the same way in both microprocessors.

2D-9. The Keyboard Output Port (U2/U3) receives address bits A10, A11, and A12 directly into the three select inputs of U2 (8-bit addressable latch). The enable input for the latch comes from the CRU Address Decoder and results from the decoding of A3, A5, and A6 (port select). By assigning a binary weight to A10, A11, and A12, the microprocessor can set any of the eight latches in U2 to a 1 or 0 with the CRUOUT line. The process just described is the same for all the output ports in this Module. The outputs from this port serve two purposes:

1. The U2 outputs 0, 1, 2, and 3 become PKSO through PKS3 (Programmer Keyboard Strobe) and leave the Video/Keyboard Module to act as binaryy weighted inputs to a decoder in the Programmer Keyboard electronics. This decoder decodes the four PKS lines to enable one of eight column select lines. If any key on that column is depressed on the Keyboard, the code for that key appears on the KRO through KR7 (Keyboard Row) lines on the input to the Video/Keyboard Module. The program routine in the PROM scans the keyboard by incrementing the count on PKS0 through PKS3.

2. The U2 outputs 4, 5, 6, and 7 act as inputs to U3 (BCD to decimal decoder). U3 decodes these outputs to create 1 of 10 OKS (Operator Keyboard Scan) signal lines which leave the Video/Keyboard Module to scan the rouch-sensitive grid columns. If any switch is the touch-sensitive matrix is closed in the selected column, the code for that switch position appears on the KRO through KR7 inputs to the Video/Keyboard Module.

3. The ROM routine must generate the scan signals for both keyboards one at a time, over and over again. In addition, it causes the microprocessor to perform the following analysis:

   a. A key must remain valid for a minimum time (contact de-bounce).

   b. If more than one key is depressed, the output is inhibited (N-key lockout).

   c. If more than one Touch-Sensitive Display key is depressed, only one location is sent out.

   d. If a key is depressed for approximately 1 second, the output is repeated.

2D-10. ASCII CODE GENERATION

2D-11. The KRO through KR7 lines act as inputs to U5, a multiplexer. By placing the correct port address on A3, 5, and 6, the microprocessor enables U5, and the A10, 11, 12 lines select one of eight KR lines as the output of U5. This output acts as input to the microprocessor (CRUIN) enabling it to read the selected bit in the port. (The process just described is the same for all input ports in the Module.) The ROM program causes the microprocessor to read all eight KR lines one at a time and, if any valid character code (key depressed or grid switch closed) is present, the microprocessor converts the code for transmission to the CPU Module as follows:

1. If a key on the Programmer Keyboard is depressed, the output is the ASCII code of that key with the eighth bit equal to 0.

2. If a grid switch is closed on the Touch-Sensitive Display, the output is a binary number from 1 to 60 with the eighth bit equal to 1.

3. If a remote keyboard is implemented (both CTRL and SHIFT on) theoutput is a binary number from 61 to 124 with the eighth bit equal to 1. The available Remote Keyboard Cable does not allow 16 of the numbers in this range to be used.

2D-12. DISPLAY MEMORY

2D-13. The microprocessor stores the ASCII coded character received from the CPU module in a static RAM display memory. The position of the cursor determines the memory location. The Display Memory capacity is 2048 bytes. The microprocessor uses this capacity in a certain layout as shown in Figure 2D-2, Display Memory. The memory holds 16 rows of 128 bytes, as shown. The first 80 bytes in each row are the 80 characters to be displayed in one row of text on the CRT screen. The next 48 bytes in each memory row make up the scratchpad RAM for the microprocessor and can contain such things as workspace register files and buffers.

2D-14. CLICKER

2D-15. If the code received on the KR lines is for a Programmer Keyboard key, the ROM program produces an audible click inside the keyboard to provide feedback to the keyboard operator. To do this, the microprocessor sets bit 6 in the General Purpose Output Port U17 (8-bit addressable latch) to a 1. The latch output triggers a one-shot (U19) whose output leaves the Video/Keyboard Module as the Clicker signal to the Programmer Keyboard which has a transducer (solenoid) that makes the click sound.

2D-16. INTERRUPTS

2D-17. The external Interrupt circuit pulls the DI08 line low during RINT if there is a character ready to be sent to the CPU Module via the UART (Universal Asynchronous Receiver Transmitter) Interface. This serial interface is made up of two UARTs of the same type described for the RS-232-C Ports in the CPU Module section.

2D-18. INTERFACE TO THE 1720A BUSES

2D-19. The microprocessor in the Video/Keyboard Module uses the first UART (U28) to send a character to the second UART (U10). The CPU Module uses the second UART to send the character to itself, via the 1720A CRUIN bus line. The detailed sequence of events is as follows:

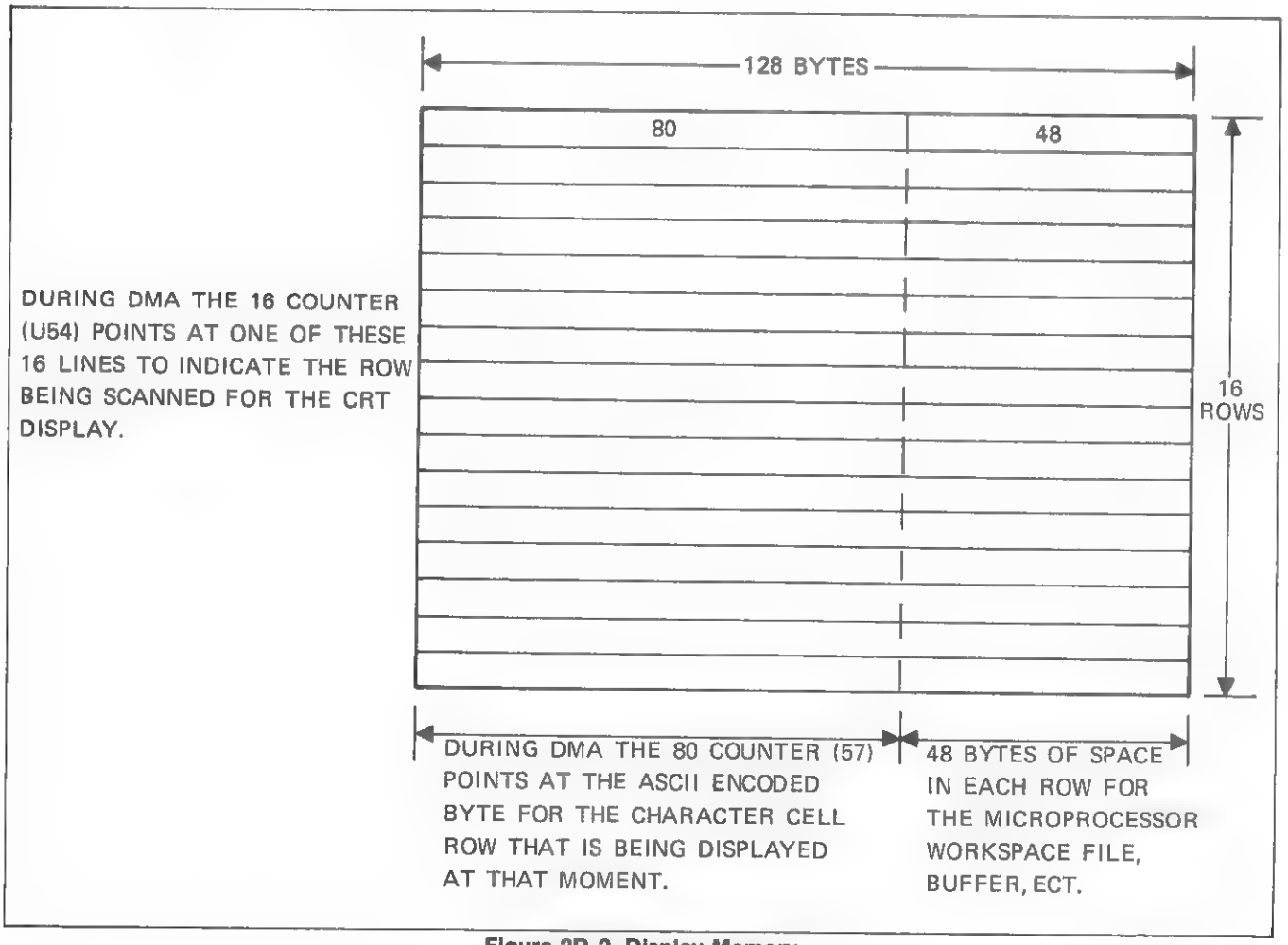


Figure 2D-2. Display Memory

1. The microprocessor uses its CROUT line (VAD00 at CRUCLK time) to load the transmit buffer in U28 with the character that is ready to be sent. This would be a character from one of the keyboards.

2. The microprocessor initiates transmission of that character via XOUT on U28 to RIN on U10.

NOTE

The microprocessor can go on to other tasks after step 2.

3. When U10 has received the character, it generates an INT (Interrupt) output that puts a low level on the input of the gated line-driver U7.

4. The RINT signal from the CPU Module gates U7 on, and the output of U7 goes low to pull D108 low.

5. As soon as the CPU Module can recognize this level of interrupt, it causes U10 to send the character on the 1720A Bus CRUIN line.

6. If the CPU Module wishes to send a character to the Video/Keyboard Module for either control purposes or for display, the reverse of the above occurs. U10 receives the characters from the CPU Module and U28 passes it on to the microprocessor. The microprocessor stores the characters sent to it for display in the Display Memory, as described earlier, and acknowledges the receipt of the input via the Serial Interface.

2D-20. DISPLAY FORMAT

2D-21. The microprocessor acting under the direction of inputs from the CPU Module and its own ROM program, establishes the display format by programming the CRT Controller. Keep in mind that the CRT display can be either in regular size characters or double size characters. The CRT Controller can be programmed to generate from 1 to 80 characters per row but generates either 80 or 40 characters in the 1720A. It can be programmed to generate from 1 to 64 rows per frame but generates 16 or 8 in the 1720A. In addition, the number of lines (horizontal sweeps) per character row can be programmed from 1 to 16 but is programmed for 14 in the 1720A. The dot width is a function of the Dot Clock frequency. Character width is a function of the Character Generator output (discussed later). The discussion that follows deals with the generation of regular size characters. Double size character generation is described later in this section.

2D-22. CRT CONTROLLER

2D-23. The CRT Controller has the responsibility of interfacing the CRT raster scan display to the microprocessor. Its primary function is to refresh the display by buffering the Display Memory information and to keep track of the display position on the screen. It has special features to generate the cursor, highlight characters, underline characters, reverse video, and supress video. In addition, it uses DMA (Direct Memory Access) to gather the characters from the Display Memory.

2D-24. DMA FOR DISPLAY

2D-25. The CRT Controller retrieves characters from the Display Memory, using DMA, on a row-by-row basis and stores them in one of two internal row buffers. While using one of these row buffers for creating the display, it is filling the other with the next row to be displayed. This process happens over and over again to keep the 16 rows of display memory on the CRT continuously refreshed. Any changes in the contents of the display memory show up the next time the CRT Controller refreshes that particular portion of the display.

2D-26. Before the start of a frame, the CRT Controller requests DMA by setting its DRQ (Direct Memory Access Request) high. This high acts as an input to the DMA Logic which produces a HOLD input to the microprocessor in synchronization with the Clock. The microprocessor responds by setting the SC (Scroll) output bits of the General Purpose Port to the address of the line that is to be at the top of frame.

NOTE

Refer to Figure 2D-2, Display Memory. This address can be the first line in the Display Memory layout, or it can be any other line. For example, during a long listing of a program from the 1720A Main Memory, when the text fills the entire 16 lines on the CRT, the top line on the CRT display is replaced by the second line and so on until the CRT display is 15 lines long on the screen. The next line of text in the listing is then written on the screen in the bottom line. This requires that, in the Display Memory, the address of the top line of the frame change (increment) for each new line of text in the listing, and that the new line of text be stored at the old top of screen address which is now the new last line of the display.

2D-27. The microprocessor then causes the Address Decoder block output CKOF– to go low by setting A0=1 and A1=0 and bringing the CRUCLK output high. This enables U24 (a decoder). The CKOF– output goes low and sets U57 (80-counter) to a count of 0 and loads the SC0, SC1, SC2, and SC3 count into U59 (16 counter).

2D-28. Next the microporcessor floats its address and data lines and causes its HOLDA output to go high. HOLDA causes several things to occur:

1. The output of the 80 counter and the 16 counters (U57 and U54) become the memory address.

2. The DACK (DMA Acknowledge) input to the CRT Controller goes true.

3. The data from the first memory location of the line that is to be the top of the frame appears on the D0 through D7 lines.

4. The CRT Controller stores the character in one of its row buffers.

5. The CRT Controller continues generating DMA requests until the row buffer is filled. Each time HOLDA from the microprocessor goes true, the 80 counter increments. Every 80 counts, the 16 counter increments. Thus, the 16 counter contains the line number (0 through 15) and the 80 counter contains the character number (1 through 80) of the character within the line.

2D-29. CHARACTER GENERATION

2D-30. As soon as the first row buffer is full, the CRT Controller begins to send characters from the beginning of the buffer tothe Character Generator and simutaneously begins to fill the second row buffer. The character Generator has two inputs:

1. The CC0 through CC6 character code outputs of the CRT Controller.

2. The output of a counter (U35) that increments once for each HRTC (Horizontal Retrace) output of the CRT Controller.

NOTE

Refer to Figure 2D-3, Character Cell. The character that is on the CRT display occupies a 7X9 dot matrix in a character cell that is an 8X14 matrix. The top line in the character field is always blank to provide a space between characters on different rows. The output of U36 goes to all zeros (blank line) when the RS inputs go to all ones (count of 15 from U35). This occurs at the first line of each character when U35 gets an active (low) LD (Load) input. The LD input to U35 goes active (low) at the first horizontal line in the row due to the VTRC (Vertical Retrace) output of the CRT Controller. Thereafter, it goes low every time U35 reaches a count of twelve which occurs every 14 horizontal lines (see the RS Input To U36 on Figure 2D-3).

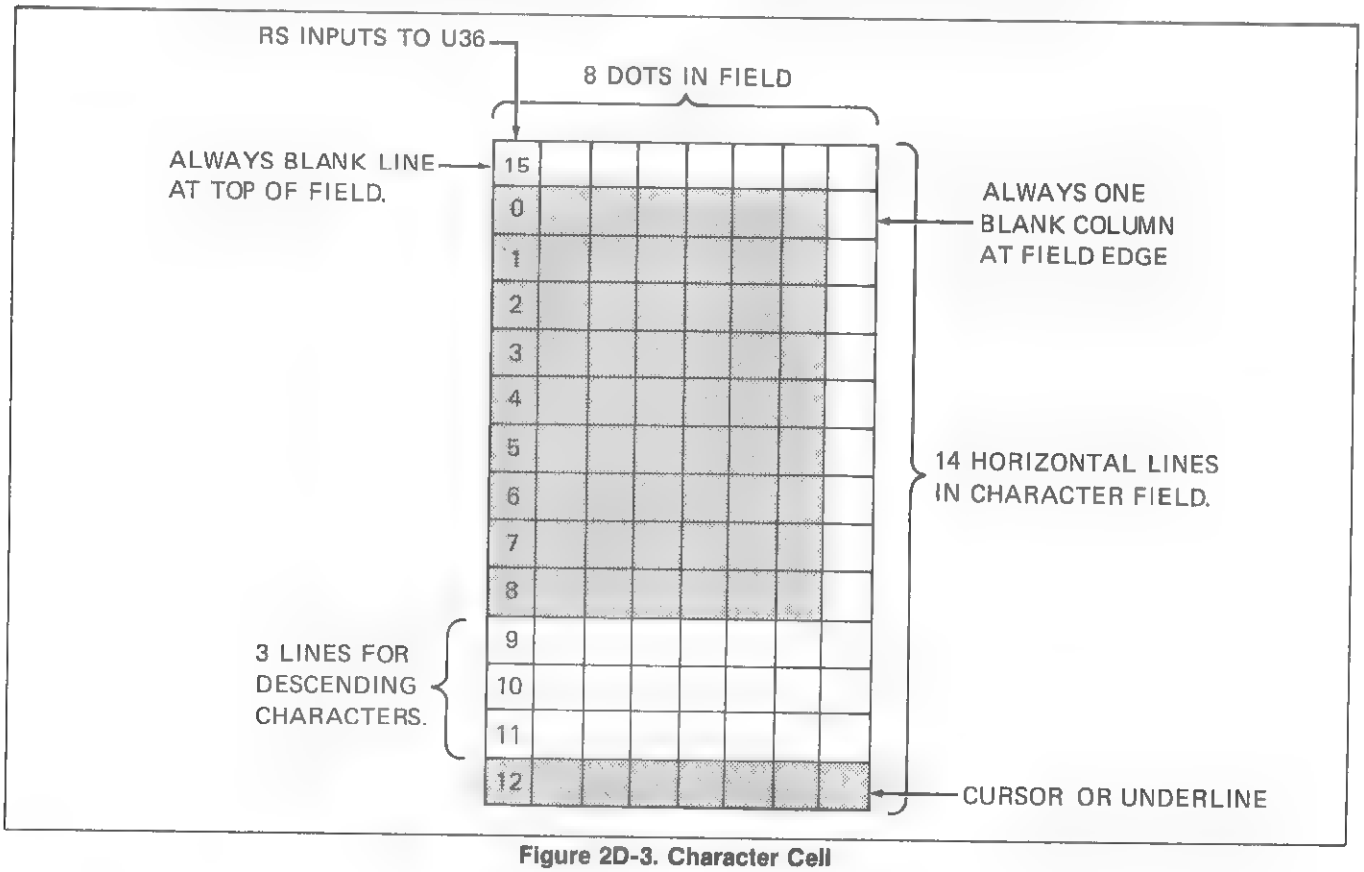


Figure 2D-3. Character Cell

2D-31. The Character Generator knows which CRT horizontal line within the character row (determined by the output of U35) it is working on, and it knows which character is has to display (CC0-CC6). The CC0-CC6 output of the CRT Controller is actually a memory address for the ROM of the Character Generator ROM. The ROM contents produce a pattern of seven ones and zeros for that particular line in that particular character. This pattern is the D0-D6 outputs of U36. The D0-D6 outputs act as inputs to a two to one multiplexer (U37/U38).

2D-32. The other inputs to the multiplexer provide graphic characters (generated by the CRT Controller). Decoding the LA0 and LA1 (Line Attribute Outputs) provides specific patterns. The use of graphic characters directly from the CRT Controller allows a graphic character to occupy areas of the cell outside the 7X9 matrix. This makes continuous lines between character cells possible.

2D-33. The 7-bit pattern from the multiplexer (U37 and U38) provides a parallel input to a shift register (U39). The shift register shifts the bits out serially at the Dot Clock rate to produce the video output of the Module. The Dot Clock rate determines the display dot width. The various modifiers from the CRT Controller, such as High Light or Reverse Video, control the CRT presentation of these dots. This process continues for each character in the row, as shown in Figure 2D-4. Each HRTC (Horizontal Retrace) increments the RS inputs to the Character Generator until all 14 horizontal lines in the character row are on the display.

2D-34. DISPLAY REFRESH AND SCROLLING

2D-35. As soon as the display of a row is complete, the CRT Controller reverses the roles of the two row buffers and begins to display the next row in the Display Memory. This process continues until the complete frame is on the CRT (16 rows). As soon as this is done, the entire frame-display process repeats, going to the Display Memory addresscontained in the 16 counter. This address should now be back at the original address of the top line in the display. This repetition of the same rows over and over again refreshes the CRT display.

2D-36. The microprocessor may also scroll the display. It does this by incrementing the scroll address, setting the 16 counter to this new value, and re-writing the previous scroll address Display Memory contents with a new line of text. The line pointed to by the new scroll address then appears at the top of the CRT Display, and the new line of text appears at the bottom of the CRT display. In either case, the contents of the Display Memory can be changed to change the CRT Display.

2D-37. CURSOR/BAUD RATE

2D-38. As stated in the introduction, the CRT Controller is capable of generating four types of cursor. It can place this cursor at any character location on the display by programming the CRT Controller. This is done by writing the appropriate information into a cursor row register and a character position register within the CRT Controller. The CRT Controller does the rest. In addition, the microprocessor reads the settings in S1 (positions A and B) from the S1 Input Port and programs the CRT Controller for the appropriate cursor. Refer to Table 2D-1.

2D-39. The microprocessor obtains the baud rate for data transmission by reading S1 switch settings C, D, and E from the RS-232 Port (P1) on the module. This Port is not used in the 1720A. The various jumper meanings appear in Table 2D-1.

2D-40. VIDEO

2D-41. This discussion on video is limited to the display of regular size characters. See Figure 2D-3, Character Cell.

2D-42. The purpose of the video outputs (VIDEO, HORIZ and VERT) is to produce a row of 80 cells across the CRT screen and make a display of 16 rows. Keep in mind as this discussion proceeds that the CRT Display Electronics produce a free running horizontal sweep from left to right that scans downward on successive sweep lines. A horizontal retrace occurs at the end of each line. When the sweep reaches the bottom of the screen it does a vertical retrace to the top of the screen and repeats the process. The HORIZ and VERT outputs of the Video/Keyboard Module, therefore, do not have to generate the sweep. Instead, they synchronize the sweep with the VIDEO output which intensity modulates the trace into a series of dots and spaces. The Video Suppress output of the CRT Controller suppresses the trace during the horizontal and vertical retrace times.

2D-43. Figure 2D-5 shows the four video signals under discussion and gives timing details for each. Use the following information to analyze Figure 2D-5:

1. The Video Suppress pulse (U40, pin 12) occurs once per row at the end of each row. It is 20 Character Clock pulses wide (to accomodate horizontal retrace) except at the end of the 16th row where it is 42 horizontal line periods wide (to accomodate vertical retrace).

2. The Horizontal sync pulse (HORIZ) occurs after the start of the Video-Suppress pulse (2.3 uS delay determined by U51 and has a width of 4.5 uS (determined by U52). It has a rate of 15960 Hz.

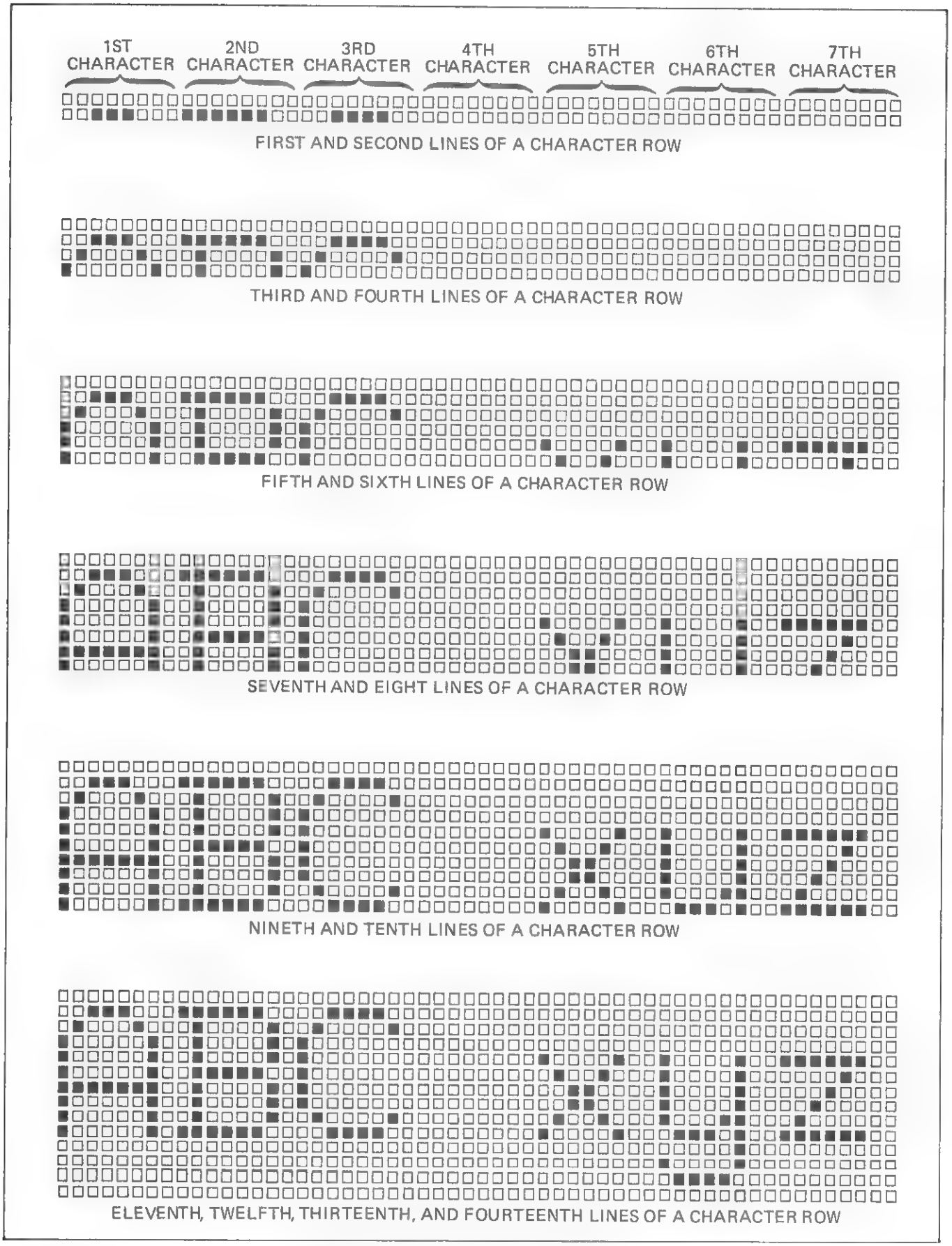


Figure 2D-4. Display of Charater Row

Table 2D-1. Cursor/Baud Rate Jumpers

A	B	C	D	E	
		●	●	●	Cursor = blinking reverse video block
X		●	●	●	Cursor = non-blinking reverse video block
	X	●	●	●	Cursor = blinking underline
X	X	●	●	●	Cursor = non-blinking underline
●	●				Baud rate = 9600
●	●	X			Baud rate = 4800
●	●		X		Baud rate = 2400
●	●	X	X		Baud rate = 1200
●	●			X	Baud rate = 600
●	●	X		X	Baud rate = 300
●	●		X	X	Baud rate = 150
●	●	X	X	X	Baud rate = 110

X = jumper
● = don't care

Note: The baud rate must be 4800 to communicate with the 1720A Bus.

3. The Vertical sync pulse (VERT) occurs at the end of the 16th row, and is delayed by 19 horizontal line periods (1.1 ms determined by U51). It isthree horizontal line periods wide (190us determined by U52) and has a rate of approximately 60 Hz. The display is not interlaced.

4. There is one video pulse for each dot on the CRT, and the absence of a pulse causes a blank space that is one dot wide. When using the character ROM (U36), the eighth pulse in any given character cell is always a blank (missing). This creates the blank space at the edge of each cell which makes the space between adjacent characters on the CRT display. There are 80 character cells of 8 pulses for each trace. The pattern of pulses and blanks in these 80 cells determines the dots and blanks in that horizontal trace. It takes 14 horizontal traces to build up one row of characters on the CRT display.

2D-44. Figure 2D-4, Display of a Character Row, shows how the 14 horizontal traces build up a hypothetical row of seven characters on the CRT display. Remember that it takes 16 rows of 80 characters to complete one CRT display of normal size characters.

2D-45. The ground on pin-14 of U38 produces the one blank dot per field. The output of U38 provides part of the parallel input to the VIDEO output at the Dot Clock rate. The dot clock output (U18, pin-8) determines the pulse width which determines the dot width on the screen.

2D-46. The video suppression output of the CRT Controller is used to suppress the horizontal retrace at the end of each horizontal line and the vertical retrace at the end of the 16th line. This high level output acts as the D-input to the quadruple D-type latch (U40). The high level produced on the Q3 output by this signal disables the blanking gate (U63) to blank the trace. This output also provides display blinking capability.

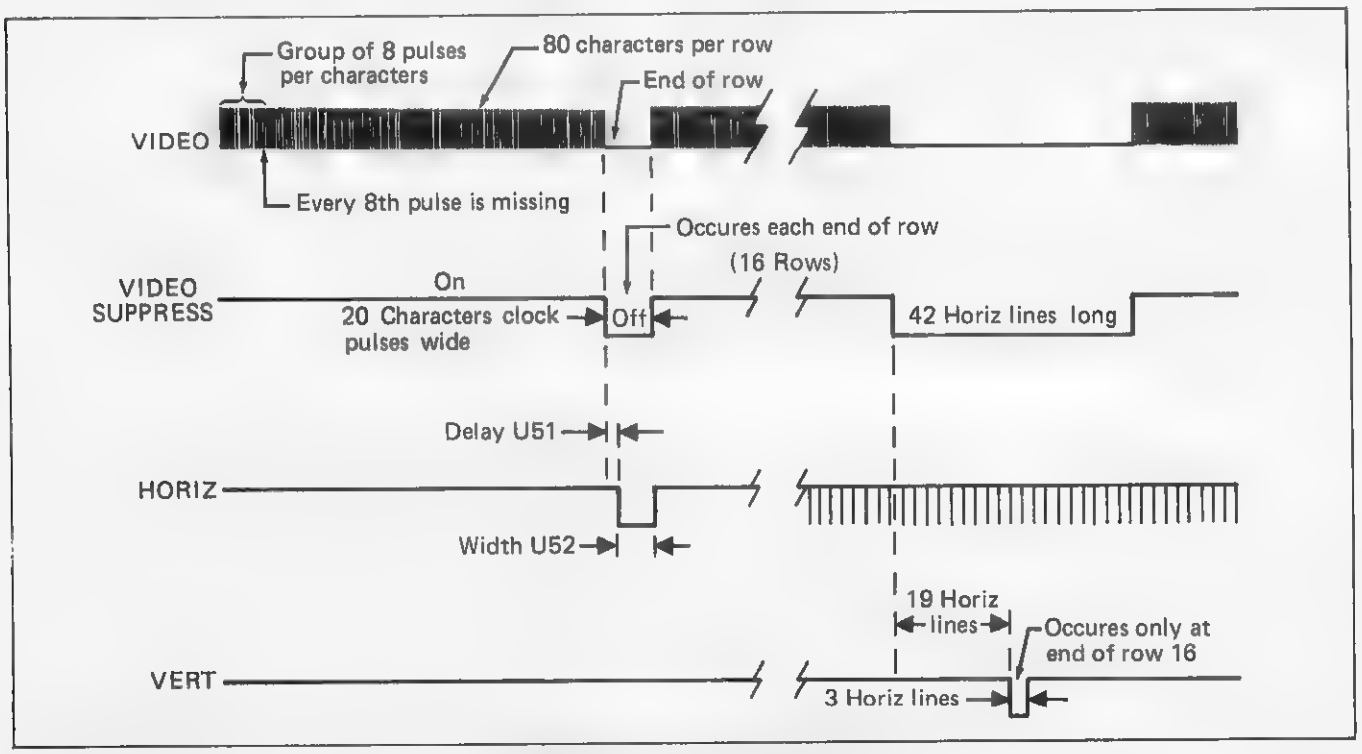


Figure 2D-5. CRT Video Signals

2D-47. The load input for U40 comes from an 8-bit counter (U22) which counts the Dot Clock output. As a result, U40 gets loaded with new video control data at the end of every character. Therefore, the latched video suppress output (pin 12) is always a multiple of eight dot Clock pulses (one character). At the end of the last character in a row, it is 20 characters (160 Dot Clock pulses) long. At the end of the 16th row, it is three character rows (42 horizontal lines) long.

2D-48. DOUBLE SIZE CHARACTERS

2D-49. To get double size characters, the microprocessor sets bit 4 in the General Purpose Output Port to a 1 (high). This causes two events to occur:

1. The output of a divide-by-two counter (U16, pin-9) begins to pass through U23 pin-3 because of the high level on pin-1. This causes U35 to count every other HRTC (divide-by-two). This makes each dot on the CRT display two horizontal lines tall instead of one.

2. The high level on pin-8 of U34 disables that NAND gate to block the full frequency Dot Clock from reaching OR gate U18 pin-10. As a result, only the 1/2 frequency Dot Clock from the divide by two output of U21 pin-5 reaches the clock input of U39. As mentioned earlier, the Dot Clock rate on this shift register determines the display dot width. The 1/2 rate makes the dots twice as wide and increments the character address (via CCLK on the CRT Controller) only 40 times per trace.

2D-50. In addition to the hardware considerations mentioned in the previous paragraph, the software must load the Display Memory for double size characters. This is done by duplicating the first 40 character positions in each row in memory and by using only eight rows of memory. The repeated horizontal trace scans the second set of 40 characters.

2D-51. BEEPER

2D-52. To create the beeper tone, the microprocessor, under the direction of the user software, places the correct code for CKON– on its A0 and A1 lines (A0=0 A1=1) and produces CRUCLK to enable decoder U24. The CKON– output of U24 goes low to trigger the one shot U19. The output of the one-shot turns on the tone generator (U64) for the duration of the pulse. The output of U64 drives a transducer to make the beep tone.

2D-53. LEDS

2D-54. The LED #1 through LED #7 outputs of the Video/Keyboard Module are the outputs of the 8-bit addressable latch U4. The microprocessor, under software direction, can set each of these outputs to either a one (on) or a zero (off). LED #1 through LED #5 go to the front panel receptacle from the Programmer Keyboard and LED #6 and 7 go to the Remote Interface. Keep in mind that these outputs are latched TTL levels (open collector) and as such could be used for a variety of purposes besides lighting the keyboard LEDs. When combined with the four PKS inputs, they make up an I/O Port to the 1720A that is available at the front panel for test or control purposes.

2D-55. CAPS LOCK LED

2D-56. The Caps Lock LED in the Programmer Keyboard receives a drive signal from the Video/Keyboard Module under software control in response to a caps lock key depression. The microprocessor produces this signal by setting bit 5 in the General Purpose Output Port to a one. When the module is first initialized, this LED is on.

2D-57. PAGE MODE LED

2D-58. The Page Mode LED receives a drive signal from the Video/Keyboard Module under software control in response to a page mode key depression. The microprocessor produces this signal by setting bit-7 in the General Purpose Output Port to a one. When the Module is first initialized, this LED is off.

2D-59. COMPOSITE VIDEO

2D-60. The Composite Video output is a 1 volt peak-to-peak signal into a 75 ohm load. This signal is easily verified at J24 (Phono Jack). Since it is a combination of all three video outputs, a voltage check is a quick way to verify its presence.

2D-61. TEST MODE OPERATION

2D-62. With S2 (NORMAL/TEST Switch) in the TEST position, the Video/Keyboard Module does not interface with the CPU Module via the 1720A CRU Bus. In this mode of operation, the microprocessor operates as usual, using the same ROM program as before. However, because S2 changes two signal paths, the results are different. Notice that with S2 in the test position, the XOUT output of U28 goes to the RIN input of U28 instead of going to U10. Notice also, that the RTS output of U28 goes to the CTS input of U28 instead of going to U10. These two changes effectively eliminate U10 and its interface to the CPU Module from the operation of the

system and allow the Video/Keyboard Module to display characters on the CRT directly.

2D-63. This direct display of characters begins when a key is pressed. The microprocessor proceeds to load the transmit buffer of U28, just as before. Now, however, U28 immediately loads its own receiver buffer instead of sending the character to the receiver buffer of U10. As soon as this buffer is full, U28 interrupts the microprocessor via the UINT- line. The microprocessor proceeds, under the ROM program control, to read the character in on its CRUIN line. When this operation is complete, the microprocessor stores the character in the display memory. The character then gets displayed just as if the character had come from the CPU Module. Note that the CTRL key modifier does not function normally because there is no software to generate a display code from two keys that are pressed in sequence but meant to be handled as if they were one key.

Section 2E
DMA-Floppy Module

2E-1. INTRODUCTION

2E-2. This discussion divides the DMA-Floppy Module into two functional circuit groupings:

1. DMA Controller and associated circuits.

2. Floppy Disk Controller (FDC) and associated circuits.

2E-3. These two circuit groups work together, under the direction of the CPU Module, to write and read data blocks on the built-in Floppy Disk drive unit. This process uses DMA (Direct Memory Access) to transfer the data to and from the Memory Module. In operation, the DMA-Floppy Module responds to memory mapped I/O operations by the CPU Module to receive address and control information. The CPU Module loads this address and control information into 12 different registers within the DMA-Floppy Module to control the various Module functions. After receiving this address and control information, the DMA-Floppy Module is capable of handling an entire DMA block transfer on its own.

2E-4. DMA CONTROLLER GENERAL DESCRIPTION

2E-5. Refer to Figure 2E-1. Notice the DMA Controller. It contains eight addressable registers and controls the byte mode DMA data transfers, with handshake, between the Floppy Disk Controller and the Memory Module. The following paragraphs describe the operation of the DMA Controller. Because the overall operation of the DMA process may not be apparent in all this data, it may be necessary to look ahead to the two topics that present the DMA operational flow (Module-To-Memory and Memory-To-Module DMA Transfers) and refer back to the details as necessary.

2E-6. Table 2E-1 presents the address, name and a brief description of all the registers in the DMA-Floppy Module. Look at the eight registers associated with the DMA Controller. A detailed description of each register appears in the following text. For now, note the function of these eight registers and remember that the CPU Module can use the register address to access each register with the Memory Mapped I/O process that was discussed in the CPU Module theory.

2E-7. The DMA Control Register (CR) holds the control command from the CPU Module. Each bit has a specific use, within the DMA Controller, as shown in Table 2E-2. Refer to the Schematic to locate specific signals.

2E-8. The Transfer Count Registers (TCR) are two 8-bit registers that hold the twos complement of the transfer count (in bytes) for DMA transfer operations. The DMA Controller increments the count by one after every DMA transfer. When the count reaches zero, bit 3 in the Status Register goes to a 1. If bit 3 in the Control Register is also a 1 then INTR– goes low also, providing the STOPR (STOP Request–) input to the IC is also high. Note that the STOPR– input is the 1720A ControlBus signal RQIN– (refer to the CPU Module theory.

2E-9. The Memory Address Registers (MAR) are two 8-bit and one 2-bit registers. The upper two bits (AD16 and AD17) need bit 6 in the Control Register set to a 1 before they are active. If bit 6 in the Control register is set to a one, then bit 16 in the Memory Address Register works as a carry from bit 15. The DMA Controller increments the contents of the Memory Address Register by one after every DMA transfer.

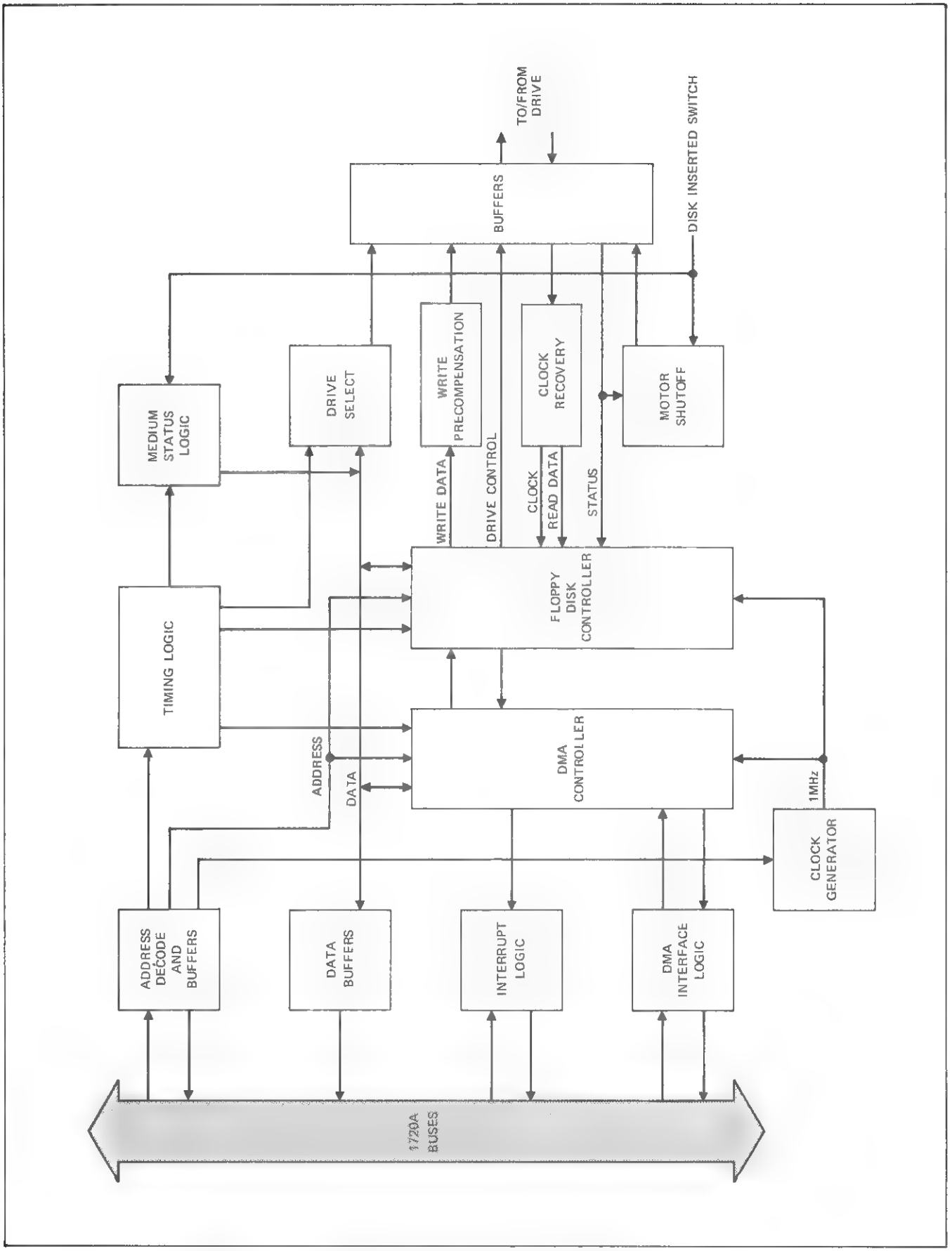


Figure 2E-1. Floppy Block Diagram

Table 2E-1. Register Address Assignments

ADDRESS	REGISTER	FUNCTION
3F3E0	STATUS/COMMAND	Floppy Status/Command
3F3E2	TRACK REG	Floppy current head position
3F3E4	SECTOR REG	Floppy address of desired sector position
3F3E6	DATA REG	Floppy parallel 8-bit read/write holding register
3F3E8	DRIVE UNIT SELECT/ MEDIUM STATUS	Disk drive unit select/ Medium Status
3F3F0	DMA CONTROL REG	8-bit DMA Controller control register
3F3F2	DMA STATUS REG	DMA Controller Status register
3F3F4	DMA TRANSFER COUNT Lower Byte	DMA Controller lower 8-bits of twos complement of the transfer count
3F3F6	DMA TRANSFER COUNT Upper Byte	DMA Controller upper 8-bits of twos complement of the transfer count
3F3F8	DMA MEMORY ADDRESS Lower Byte	DMA Memory Address, low byte
3F3FA	DMA MEMORY ADDRESS Upper Byte	DMA Memory Address, high byte
3F3FC	DMA MEMORY ADDRESS EXTEND	DMA Memory Address, two bit extension of memory address
3F3FE	DMA INTERRUPT VECTOR	Not used in 1720A

Table 2E-2. DMA Controller Control Register

BIT	SYMBOL	FUNCTION
0	RUN	Run/Stop bit. A 1 places the DMA Controller in the run mode. A 0 terminates DMA Controller operation.
1	DIE	Device Interrupt Enable. A 1 allows a high input on DINTR to set the INTR- output low.
2	TOIE	Time-Out Interrupt Enable. A 1 allows the time-out one-shot to set the INTR- output low. The DMA Controller sets the time-out interrupt during a DMA transfer if REPLY- does not go low within 5 us of MSYNC- going low, as discussed later.
3	TCIE	Transfer Count zero Interrupt Enable. A 1 allows a zero in the transfer count register to set the INTR- output low.
4	IOM	Input or Output Mode. A 1 sets READ mode (which sends data from DMA-Floppy Module to Memory). A 0 sets WRITE mode (which sends data from Memory to DMA-Floppy Module). This bit appears on the R/W- pin of the I/C. The BUSWR- output of the Module is RW- inverted.
5	HBUS	Hold BUS. A 1 informs the DMA Controller to hold onto the bus for the entire block instead of releasing the bus after each byte or word transfer. Not used in the 1720A.
6	AECE	Address Extension Carry Enable. A 1 allows a carry from DMA address bit 15 to propogate into bit 16.
7	N/A	Not used.

NOTE

The DMA Controller gates the DMA address onto the DAL (Data Access Lines) outputs in two 9-bit bytes. The first byte out contains MAR bits 8-15 on DAL 0-7 and MAR bit 17 on AE8 (Address Extension 8). The second byte out contains MAR bits 0-7 on the DAL 0-7 lines and MAR bit 16 on AE8. The first byte is valid on the trailing edge of the BUSR- (BUS Request) output and the second byte is valid on the trailing edge of the LAL- (Load Address Low) output.

2E-10. The Status Register (SR) is an 8-bit register that indicates the status of the DMA Controller. Table 2E-3 presents details.

2E-11. Module-To-Memory DMA Transfers

2E-12. This operation takes place when the 1720A reads a block of data from the Floppy Disk into the Memory Module. This topic does not deal with the operation of the Floppy Disk Controller IC or the interface to the Floppy Disk Drive unit which are discussed later. For now, the only concern is the DMA data transfer itself. The following paragraphs cover the operational flow for this transfer.

2E-13. It is assumed that the CPU Module has set up the transfer by: programming the Floppy Disk Controller, loading MAR (Memory Address Register), loading TCR (Transfer Count Register), and placing the appropriate command into the CR (Control Register).

2E-14. When the DMA Controller is in the RUN mode (CR bit 0=1) it waits for a Data Request (DRQ) input) from the Floppy Disk Controller. This event occurs when the Floppy Disk Controller has a data byte from the Floppy Disk ready to go into memory. When DRQ becomes active (high), the BUSR- (BUS Request) output of the DMA Controller becomes active (low). This low acts as an input to the DMA Interrupt Logic block, which responds by asserting the RQOUT- (low) output of the Module to request control of the system buses.

NOTE

If the RQIN- input to the Module is active (low) when DRQ goes active, the DMA Controller waits until RQIN- goes high before bringing BUSR- low.

2E-15. As soon as GRIN goes low, the DMA Controller has control of the system buses and goes on with the DMA transfer. It controls the direction of the transfer by the status of the R W output pin which is tied directly to CR bit-4 (refer to Table 2E-2). The DMA Logic block inverts the R/W output and places the result onto the BUSWR- line of the 1720A Control Bus. Since R/W- is high (Read), BURWR- goes low for this operation to indicate the DMA transfer is sending data to the Memory Module.

Table 2E-3. Status Register

BIT	SYMBOL	FUNCTION
0	BOW	Byte Or Word data channel. A read only bit that indicates the status of the BOW input pin (always high in the 1720A for byte mode).
1	DINT	Device Interrupt. If set to a 1, a device interrupt has occurred (set by the Floppy Disk Controller IC to indicate command complete). This is a read/write bit. Resetting this bit to a zero resets the INTR- (Interrupt Request) output of the DMA Controller. Refer to DMA Interrupt topic.
2	TOI	Time-Out Interrupt. If set to a 1 then a time out error has occurred. This is a read/write bit. Resetting this bit to a zero resets INTR-. Refer to DMA Interrupt topic.
3	TCZI	Transfer Count = Zero Interrupt. If set to a 1 then a transfer count equal zero interrupt has occurred. It is a read only bit that sets the EOB (End of Block) output when set. Refer to the DMA Interrupt topic.
4	IOM	Input-Output Mode. A read only bit that reflects the status of bit 4 in the Control Register.
5	HBUS	Hold Bus. A read only bit that reflects status of bit 5 in the Control Register. Not used in 1720A operation.
6	AECE	Address Extension Carry Enable. A read only bit that reflects the status of bit 6 in the Control Register.
7	BUSY	Busy (data transfer not complete). A read only bit that reflects the status of bit 0 in the Control Register.

Note: Bit 1, 2, 3, are set if the corresponding condition occurs. The enable bits in the CR to affect only the INTR- output and not the Status Register.

2E-16. The DMA Controller places the high byte of the memory address on the DAL lines, then sets BUSR– to 1. This causes two things to happen:

1. Address Buffer U48 latches the DAL address.

2. U41 in the DMA Logic block latches the state of the AE8 output. The output of U41 becomes AD17 on the 1720A Address Bus.

2E-17. The DMA Controller places the low byte of the Memory address on the Dal lines, then sends the LAL– (Load Address Low) and MSYNC– (Memory Sync) low pulses. This causes two things to happen:

1. The trailing edge of LAL– clocks the Address Buffer U47. This latches the DAL address. In addition, the trailing edge of the pulse clocks U41 to latch the AE8 output (for the AD16 line of the 1720A Address Bus).

2. MSYNC– goes low and places a low on the BMODE– 1720A Control Bus line. Also, this low sets AD16, AD17, ADVAL– and BUSWR– on the 1720A Buses into the states determined by the DMA Controller. The state of ADVAL– is the same as the state of MSYNC– (low) but lags MSYNC– by a delay determined by the Timing Logic. This places the address on the Address Bus slightly ahead of the ADVAL– active state.

2E-18. The DMA Controller then places the DAL lines in a high impedence state in anticipation of a data transfer to the 1720A Bus from the Floppy Disk Controller.

2E-19. The DMA Controller activates RE– (Read Enable). This low level to the Floppy Disk Controller enables data flow from that device to the Data Buffers. At this time, the 1720A Control Bus Signal BUSWR– is low during the time MSYNC– is low and is an input to U27 pin 6. As a result, BUSWR– enables one input to NAND gate U32 pin 6 in the Data Buffer Block. The MSYNC– low enables the other leg and the output (pin 4) acts through U31 pin 4 to place the Data Buffers into the output mode.

2E-20. At this time several events take place at the same time:

1. The complete 18-bit address is present on the 1720A Address Bus.

2. ADVAL– on the 1720A Control Bus is low to inform the Memory Module of this fact.

3. BUSWR on the 1720A Control Bus is low to indicate that data flow is from the DMA to Memory (write operation).

4. An 8-bit data byte is present on the 1720A Data Bus.

2E-21. The DMA Controller waits for ADACK– (Address Acknowledge) from the Memory Module to make its REPLY– input active. When this happens the DMA Controller deactivates its RE– output. See the Time-Out portion of the DMA Interrupts topic.

2E-22. MSYNC– now goes high and the DMA-Floppy Module gives up control of the bus.

2E-23. After the completion of every data transfer, the DMA Controller increments the Memory Address Register by one, in preparation for the next transfer.

2E-24. After the completion of every data transfer, the DMA Controller increments the Transfer Count Register by one. The DMA Controller considers transfers to be completed when this count equals zero.

2E-25. Memory-to-Module DMA Transfers

2E-26. This operation takes place when the 1720A writes a block of data onto the Floppy Disk from the Memory Module. Again, this topic does not deal with the operation of the Floppy Disk Controller or the interface to the Floppy Disk Drive unit which are discussed later. For now, the only concern is the DMA data transfer itself.

2E-27. The operational flow of this operation is nearly the same as the Module-to-Memory flow just described. The paragraphs that follow cover the operational flow.

2E-28. It is assumed that the CPU Module has set-up the transfer by: programming the Floppy Disk Controller, loading MAR (Memory Address Register), loading TCR (Transfer Count Register), and placing the appropriate command into the CR (Control Register).

2E-29. When the DMA Controller is in the RUN mode (CR bit=1) it waits for a Data Request (DRQ) input from the Floppy Disk Controller. This event occurs when the Floppy Disk Controller is ready for a data byte from the Memory Module which would go onto the Floppy Disk. When DRQ becomes active (high), the BUSR– (BUS Request) output of the DMA Controller becomes active (low). This low acts as an input to the DMA Interrupt Logic block, which responds by asserting the RQOUT (low) output of the Module to request control of the system buses.

NOTE

If the RQIN– input to the Module is active (low) when DRQ goes active, the DMA Controller waits until RQIN– goes high before bringing BUSR– low.

2E-30. As soon as GRIN- goes low, the DMA Controller has control of the system buses and goes on with the DMA transfer. It controls the direction of the transfer by the status of the R/W- output pin which is tied directly to CR bit 4 (refer to Table 2E-2). The DMA Logic block inverts the R/W- output and places the result onto the BUSWR- line of the 1720A Control Bus. Since R/W- is low (write), BUSWR- goes high for this operation to indicate the DMA transfer is receiving data from the Memory Module.

2E-31. The DMA Controller places the high byte of memory address on the the DAL lines, then sets BUSR- to 1. This causes two things to happen:

1. Address Buffer U48 latches the DAL address.

2. U41 in the DMA Logic block latches the state of the AE8 output. The output of U41 becomes AD17 on the 1720A Address Bus.

2E-32. The DMA Controller places the low byte of the Memory address on the DAL lines, then sends the LAL (Load Address Low) and MSYNC-(Memory Sync) low pulses. This causes two things to happen:

1. The trailing edge of LAL- clocks the Address Buffer U47. This latches the DAL address. In addition, the trailing edge of the pulse clocks U41 to latch the AE8 output (for the AD16 line of the 1720A Address Bus).

2. MSYNC- goes low and places a low on the BMODE- 1720A Control Bus Line. Also, this low sets AD16, AD17, ADVAL- and BUSWR- on the 1720A Buses into the states determined by the DMA Controller. The state of ADVAL- is the same as the state of MSYNC- (low) but lags MSYNC- by a delay determined by the Timing Logic. This places the address on the Address Bus slightly ahead of the ADVAL- active state.

2E-33. The DMA Controller then places the DAL lines in a high impedence state in anticipation of a data transfer to the 1720A Bus from the Floppy Disk Controller.

2E-34. The DMA Controller activates WE- (Write Enable). This low level to the Floppy Disk Controller enables data flow from the Data Buffers into the Floppy Disk Controller. At this time, the 1720A Control Bus Signal BUSWR- is high during the time MSYNC is low and is an output of U27 pin 14. This high level becomes a low level at U33 pin 4. As a result, BUSWR- (high) enables one input to NAND gate U32 pin 11. The MSYNC- low enables the other leg and the output (pin 13) acts through U31 pin 1 to place the Data Buffers into the input mode.

2E-35. At this time several events take place at the same time:

1. The complete 18-bit address is present on the 1720A Address Bus.

2. ADVAL- on the 1720A Control Bus is low to inform the Memory Module of this fact.

3. BUSWR on the 1720A Control Bus is high to indicate that data flow is from the DMA to Memory (write operation).

4. An 8-bit data byte is present on the 1720A Data Bus.

2E-36. The DMA Controller waits for ADACK (Address Acknowledge) from the Memory Module to make its REPLY- input active. When this happens the DMA Controller de-activates its RE- output. See the Time-Out portion of the DMA Interrupts topic.

2E-37. MSYNC- now goes high and the DMA- Floppy Module gives up control of the bus.

2E-38. After the completion of every data transfer, the DMA Controller increments the Memory Address Register by one, in preparation for the next transfer. It also increments the Transfer Count Register by one. The DMA Controller considers transfers to be completed when this count equals zero.

2E-39. DMA Interrupts

2E-40. There are three individually enabled interrupt conditions associated with the DMA Controller. If any of the conditions occur, it sets the corresponding bit in the Status Register. If the appropriate enable bit in the Command Register is set, then the INTR- output of the Controller also goes active. If this happens, the interrupt Logic block produces a low on DI02 during the next RINT cycle to give an interrupt to the CPU Module.

2E-41. Once an interrupt condition sets its corresponding bit in the status register, the bit stays set until a CPU write to the Status Register occurs with a zero in the bit position. For a Transfer-Count-Equals-Zero to be cleared, the Transfer Count Register must be loaded with a non-zero count.

2E-42. A detailed description of the three interrupt conditions follows:

1. A Device Interrupt (DINT) condition occurs when the DINTR input to the DMA Controller goes high. This sets SR bit 1 and, if CR bit one is set, it activates INTR-. In addition, the Controller resets the RUN bit to zero to terminate all

subsequent DMA transfers. The interrupt service routine in the CPU Module clears the DINT status bit.

2. Transfer Count Equals Zero (TCZI). When the DMA Controller increments the TCR to zero after a DMA transfer, it sets the TCZI status bit (SR bit 3) and resets the RUN bit (CR bit 0) to terminate all DMA operations. If CR bit-3 is set, it activates INTR–.

3. Time-Out Interrupt (TOI). During any DMA transfer, the leading edge of MSYNC– triggers an internal time delay of approximately 5 microseconds. If the DMA Controller does not receive an active low REPLY (ADACK– from the Control Bus) within that time delay, it terminates the DMA operation, resets the RUN bit, and sets the TOI status bit (SR bit-2). If CR bit-2 is set, it activates INTR .

2E-43. FLOPPY DISK CONTROLLER GENERAL DESCRIPTION

2E-44. As shown on Figure 2E-1, the Floppy Disk Controller interfaces the Floppy Disk Drive to the DMA Controller and to the 1720A Buses. The discussion that follows first considers the interface to the DMA Controller and the 1720A buses, then considers the interface to the Floppy Disk Drive unit. Following this, the discussion puts everything together by going through both read and write disk operations. Refer to both the Schematic and to the DMA Floppy Disk Interface Block Diagram as the discussion progresses.

2E-45. DMA and System Interface

2E-46. The interface to the DMA Controller and to the System Buses is accomplished through the eight DAL (Data Access Lines) and associated control signals. The Floppy Disk Controller IC (called FC from now on) uses the DAL– lines to transfer Data, Status, and Control words. The DAL– buffers are tri-state buffers that function as output drivers when the CS– (Chip Select) and the RE– (Read Enable) inputs are low andfunction as input receivers when CS and WE– (Write Enable) inputs are low.

2E-47. As shown in Table 2E-1, there are four registers in the FC that are accessed via Memory maped I/O operations by the CPU Module:

1. Status Register (read)/Command Register (write)

2. Track Register (write and read)

3. Sector Register (write and read)

4. Data Register (write and read)

2E-48. Before each DMA operation, the CPU Module loads these registers as necessary to complement the command it places into the command register. The read or write reference in parenthesis after the register name in the previous list indicates what the CPU Module does to that register. The commands are discussed in the paragraphs under the Commands heading. During the DMA operation, the Data Register serves the functions already covered under the DMA portion of this discussion.

2E-49. Commands

2E-50. The FC accepts 11 commands. Command words must be loaded into the Command Register when the Busy status bit (bit 0) is set to 0. The one exception is the Force Interrupt command (discussed later). Throughout the execution of a command, the Busy status bit is equal to 1. At the completion of a command, the FC sets the Busy status bit to a 0 and issues INTRQ. The Status Register indicates whether the completed command encountered an error or was error free. For ease of discussion, this topic talks about these commands as if there were four types. Table 2E-4 presents the four types of commands and their binary code. Table 2E-5 presents the meanings of the various flag bits in the commands. The paragraphs that follow offer an explanation of the 11 commands.

2E-51. The Restore (seek track 00) command causes the FC to move the read/write head over track 00 and set the Track Register to all zeros. It issues 255 stepping (maximum) pulses to the Disk Drive and, if it does not find track 00 with this effort, sets the Seek Error status bit, then terminates the operation and activates INTRQ.

Table 2E-4. Command Summary

TYPE	COMMAND	BITS
		7 6 5 4 3 2 1 0
I	Restore	0 0 0 0 h V r1 r0
I	Seek	0 0 0 1 h V r1 r0
I	Step	0 0 1 u h V r1 r0
I	Step In	0 1 0 u h V r1 r0
I	Step Out	0 1 1 u h V r1 r0
II	Read Sector	1 0 0 m X E 0 0
II	Write Sector	1 0 1 m X E X a0
II	Read Address	1 1 0 0 0 1 0 0
III	Read Track	1 1 1 0 0 1 0 X
III	Write Track	1 1 1 1 0 1 0 0
IV	Force Interrupt	1 1 0 1 I3 I2 I1 I0

X = Don't care Note: Bits shown in TRUE form.

Table 2E-5. FLAG Summary

TYPE I
h = Head Load Flag (Bit 3) h = 1, Load head at beginning h = 0, Unload head at beginning V = Verify flag (Bit 2) V = 1, Verify on last track V = 0, No verify r1r0 = Stepping motor rate (Bits 1-0) u = Update flag (Bit 4) u = 1, Update Track register u = 0, No update
TYPE II
m = Multiple Record flag (Bit 4) m = 0, Single Record m =1, Multiple Records a0 = Data Address Mark (Bit 0) a0, = 0, FB (Data Mark) a1, F8 (Deleted Data Mark) E = 15 ms Delay E = 1, 15 ms delay E = 0, no 15 ms delay
TYPE IV
Ii = interrupt Condition flags (Bits 3-0) I0 = 1, Not-Ready to Ready Transition I1 = 1, Ready to Not-Ready Transition I2 = 1, Index Pulse I3 = 1, Immediate Interrupt

NOTE

If the 1720A Control Bus signal DCOK- goes active (low), the FC executes this command when DCOK- goes inactive (high).

2E-52. The Seek command assumes that the Track Register contains the correct track number of the current position of the read/write head and the Data Register contains the desired track number. The FC updates the Track Register while issuing stepping pulses in the appropriate direction until the contents of the Track Register are equal to the contents of theData Register.

2E-53. The Step command causes the FC to issue one stepping pulse to the Disk Drive. The stepping motor direction is determined by the last step command (Step In or Step Out) given by the DMA Floppy Module. The Step In command causes the FC to issue one stepping pulse in the direction towards track 76. The Step Out command causes the FC to issue one stepping pulse in the direction of track 00.

2E-54. The Read Sector command assumes that the CPU Module has loaded the Sector Register with the desired sector number. The FC sets the Busy Status Bit and when an ID field is encountered that has the correct track number, correct sector number, and correct CRC, (Cyclic Redundency Check) the FC presents the data field to the CPU Module via the DMA process. It must find the data address mark of the data field within 43 bytes of the last ID field CRC byte; if not, the FC sets the Record Not Found status bit (bit 3) and terminates the operation.

2E-55. The Write Sector command assumes that the CPU Module has loaded the Sector Register with the desired sector number. The FC sets the Busy status bit and when an ID field is encountered that has the correct track number, correct sector number, and correct CRC, (Cyclic Redundency Check) it sets DRQ. The FC counts off 22 bytes from the CRC field, activates the WG (Write Gate) output, then writes 12 bytes of zeros on the disk. At this time it writes the Data Address Mark on the disk as determined by bit 0 in the command. See Table 2E-5. The FC then writes the data field, generating the necessary DRQs to the DMA Controller. After the FC writes the last data byte on the disk, it writes the two CRC bytes. Then it deactivates the WG signal, and sets INTRQ.

2E-56. The Read Address command causes the FC to load the read/write head and set the Busy status bit. Then the FC reads the next ID field and assembles the next six data bytes in this field. During assembly it transfers them one at a time to the Data Register, and generates a DRQ for each byte for each transfer. The six bytes contain:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Track Addr.	Side Number	Sector Addr.	Sector Length	CRC	CRC

2E-57. The Read Track command causes the FC to load the head and set the Busy Status bit. Reading starts with the leading edge of the first encountered index mark and continues until the next index pulse. As each byte is assembled, it is transferred to the Data Register, and Data Request is generated for each byte transferred. The FC does not perform a CRC and includes gaps in the input data stream. It accumulates bytes in sychronization with each Address Mark encountered. Upon completion of the command, the FC activates the interrupt.

2E-58. The Write Track causes the FCL to set the Busy status bit, load the read/write head and start writing with the leading edge of the first encountered index pulse and continue until the next index pulse. At the completion of this, it activates INTRQ. Even though the FC sets DRQ immediately upon receiving this command, it does not start writing until after the first byte is in the Data Register. If this does not happen by the time it encounters the index pulse, the FC terminates the operation, resets the Busy status bit, and sets the Lost Data Status bit. During the operation, if a data byte is not in the DR when needed, the FC substitutes a byte of zeros. The FC writes the CRC bytes and Address marks upon receipt of certain special characters in the incoming data stream.

2E-59. The Force Interrupt is different from the others. The CPU Module can load this command into the Command Register at any time. If there is a current command under execution, the FC terminates that command and generates an interrupt when it detects the condition specified in the I0 through I3 field, as follows:

I0 = Not-Ready-To-Ready Transistion
I1 = Ready-To-Not-Ready Transition
I2 = Every Index Pulse
I3 = Immediate Interrupt

NOTE

If I0 - I3 = 0, there is no interrupt generated, but the FC terminates the current command and resets the Busy status bit. This is the only command that will clear the immediate interrupt.

2E-60. Floppy Disk Interface

2E-61. Refer to Figure 2E-1. The FC provides drive control directly to the Floppy drive unit, but uses the Write Precompensation block to provide write data and uses the Clock Recovery block to recover the read data. In addition to the FC, there is a Medium Status Logic block, a Drive Select block, and a Motor Shut Off block. This discussion covers each of these blocks as preparation for the Read and Write Operation discussions that follow. Refer to the Schematic when the discussion mentions specific signals, components and pin numbers.

2E-62. The FC has two modes of operation according to the state of pin 37. When this pin is a 1 (high), single density is selected and when it is a 0 (low), as in the 1720A, double density is selected. In either case the CLK (Clock) input frequency is 2 MHz. However, when interfacing with a small floppy (as in the 1720A), the clock input frequency is set to 1 MHz for both single density and double density. This gives stepping rates of 6, 12, 20, and 30 ms.

2E-63. Four commands (from the CPU Module) cause the FC to position the Read-Write head in the Floppy Drive (see Commands). The period of each positioning step cycle is specified by the r field in bits 1 and 0 of the command word (see ro r1 in Table 2E-4).

2E-64. The Step output (STEP) of the FC is a 4 us pulse output that becomes ISTP at the drive connector P9. For every step pulse issued, the drive moves one track location in a direction determined by the Direction output. The Direction output (DIRC) of the FC is high when stepping in and low when stepping out. It is valid 24 us before the first stepping pulse. It becomes IDIR at the drive connector P9.

2E-65. The WD (Write Data) output signal from the FC goes to the Write Precompensation block. The write data output of this block becomes the IWDA output at the drive connector P9. The Write Precompensation block determines the actual value of the write precompensation necessary for correct read back of the data bits.

2E-66. Both the RWR (Raw Read Data) and the RCLK (Read Clock) inputs to the FC come from the Clock Recovery block. This block receives read data (IRDA) from the Floppy Disk Drive in a MFM (Modified Frequency Modulation) format. It functions as a data separator and provides the RWR and RCLK inputs for the FCF.

2E-67. The Drive Select block responds to a CPU Module memory maped I/O write into the Drive Unit Select/Medium Status Register (address 3F3E8), bits 0, 1, 2, 3. This selects which of the Drive Units 0, 1, 2, 3, that the CPU Module desires to use during the next read or write operation. The Drive Select block also activates the HLT (Head Load Timing) input to the FC to allow time for completion of the head loading process in the Floppy Disk Drive Unit. This process occurs each time the CPU Module selects a new drive.

2E-68. As shown in Figure 2E-1, the disk inserted switch input (P9 pin36) to the Module from the Floppy Disk Drive Unit goes to two blocks: the Motor Shut Off block and the Medium Status Logic. The functions of these two blocks are:

1. The Motor Shut Off Block responds to any memory mapped I/O access of the DMA-Floppy I/F Clock Module by:

   a. Activating the ISLT output of P9 that goes to the selected drive if the switch input from the Drive indicates there is media present. The Drive responds by starting its motor and loading its read/write head against the media.

b. Activating the RDY (Ready) input to the FC after a delay to allow the motor to come up to speed. The FC samples this input and does not initiate any read or write operation until RDY goes high.

c. Counting the incoming index pulses (IINXP) which come from the Drive at approximately 200 ms intervals and shutting the motor off if the count reaches 80 (16 seconds).

d. Shutting off the motor if the switch input from the Drive opens (media removed).

2. The Medium Status Logic sets bit 0 in the Drive Unit Select/Medium Status Register if a disk is in the Drive and sets bit 1 each time the disk is changed.

2E-69. Head Positioning

2E-70. As mentioned previously, there are four commands that cause head positioning (see Commands). The CPU Module positions the read/write head over the correct track with appropriate commands into the command register of the FC which generates the STEP and DIRC outputs as necessary. The FC uses the input TR00 (ITRK0 at P9) which goes active (low) when the read/write head is over track zero to implement the Restore command. The CPU Module positions the read/write head before initiating read or write operations. The Track Register always has the current track address.

2E-71. Disk Read Operations

2E-72. The 8-bit Sector Register (see Table 2E-1) holds the address of the desired sector position. The FC compares the contents of this register with the recorded sector number in the ID field of the sectors in the track.

2E-73. The RWR input to the FC comes from the Clock Recovery block and is a 250 ns pulse per flux transition. Along with this signal, the FC receives a RCLK signal that indicates flux transition spacings. An 8-bit shift register assembles serial data from the RWR input into an 8-bit parallel byte of data.

2E-74. When the RE input goes low, the FC transfers the assembled data byte from the Shift Register into the Data Register and from there into thedata buffers on the DAL output lines. As mentioned in the DMA portion of this write up, the FC issues a DRQ during a read to indicate that a complete byte of data is ready. The DMA Controller responds by setting up a write memory DMA operation at the correct address and making the RE input to the FC low. Any new command resets the INTRQ output.

2E-75. Disk Write Operations

2E-76. Head positioning and sector addressing are the same as in a read. As soon as the FC finds the sector address wanted, it issues the DRQ output to the DMA Controller which responds by initiating a memory read DMA operation at the correct address and placing a byte of data on the DAL lines.

2E-77. The DMA Controller activates the WE- input to the FC, and the FC transfers the byte of data from the DAL lines to the Data Register. From here the data goes into the Data Shift register. The FC then shifts the data out of the Data Shift register to the WD (Write Data) output. As soon as the Data Shift Register is empty, the FC issues another INTRQ to the DMA Controller for the next byte of data.

Section 2F
Power Supply

2F-1. INTRODUCTION

2F-2. The 1720A Power Supply provides all the operating voltages required by the other modules and provides battery derived supply voltages for powering the electronic disk. Figure 2F-1 shows the three PCBs that make up the Power Supply and shows the functional blocks within each PCB.

2F-3. SWITCHING POWER SUPPLY

2F-4. The Switching Power Supply operates at 50 kHz. It operates over a line frequency and voltage range of:

VOLTAGE RANGE	LINE FREQUENCY
90V to 132V	47 Hz to 63 Hz
192V to 250V	47 Hz to 63 Hz
104V to 126V	380 Hz to 420 Hz

2F-5. It provides the following output voltages:

5VDC at 8A
12VDC at 1.5A
12VDC at 2A
-12VDC at 1A
70VDC at 0.4A

2F-6. The components that make up the Switching Power Supply span all three PCBs. The paragraphs that follow present the theory of operation for this supply. Refer to both the Block Diagram and to the schematic as the discussion progresses. When referring to the schematic, notice that the particular PCB (or PCBs) on any given page of the schematic is indicated by a four digit number. These numbers mean:

1006 Power Supply Control PCB
1007 Power Supply Rectifier PCB
1016 Switching Transistor PCB

2F-7. ±HV SUPPLY

2F-8. The ±HV Supply is on the P/S Control PCB. The supply consists of the Line Transient Suppression Block, the Inrush Current Limit Block, the Rectifier and Filter, and the Common Mode Filter.

2F-9. The incoming line voltage enters the supply through F1 and passes through the Line Transient Suppression circuit. Relay K1 is open at this time (start up), therefore, the current passes through RT1 which is a thermistor offering a higher resistance while cold. This provides the Inrush Current Limit function. Diode CR4 rectifies the line voltage and, if S3A is in the 240V position, acts as a bridge rectifier. If S3A is in the 120V position, CR4 acts as a voltage doubler. In either case, the supply capacitors C1 and C2 charge up to ±170V. The Common Mode Filter provides appropriate filtering for the final ±170V output on P18 pins 1 (+HV) and 5 (-HV).

2F-10. Notice that the relay K1 closes as the -12V supply comes up. The only function of K1 is to bypasss RT1 after the supply is up and regulating. This allows RT1 to cool off and be ready to provide inrush current protection again if the supply shuts down and comes back up. In addition, the bypass eliminates the power loss caused by the incoming current passing through RT1.

2F-11. The Spark Gap E1 is used only in the 120V mode. Its function is to breakdown and blow the fuse if the supply is plugged into 240V while S3 is in the 120V position. This prevents damage to the supply components.

2F-12. The ±HV Outputs just discussed go directly to the Switching Transistor PCB. Before going into the theory of operation for this PCB and the power Supply Rectifier PCB, it is necessary to discuss the Pulse Width Modulator that provides the input to the Drive Circuit.

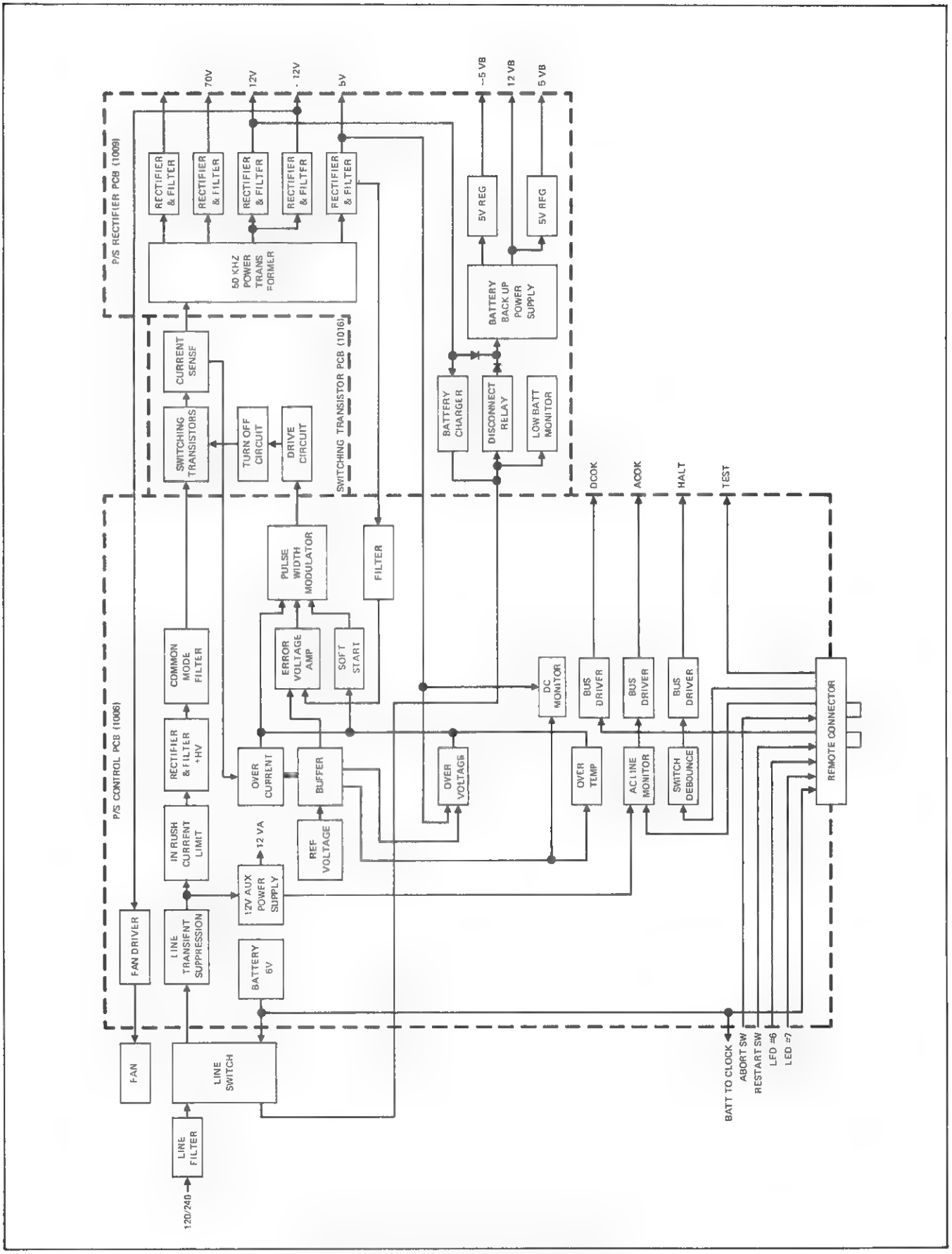


Figure 2F-1. Power Supply Block Diagram

2F-13. PULSE WIDTH MODULATOR AND CONTROL

2F-14. As soon as S1 closes, incoming power goes to the Start Up Supply as well as the ±HV Supply. The Start Up Supply, consisting of T2, CR1, U4 comes up must faster than the ±HV Supply. It provides +12V through CR13 to activate the Pulse Width Modulator and Control circuits during the time it takes the main +12V supply to come up. As soon as the main +12V supply voltage is up to +12V, CR13 is reverse biased effectively disconnecting the Start Up Supply.

2F-15. The Pulse Width Modulator IC, U5, responds to the sense input on pin 6 by changing the width of the 50 KHz output pulses on pins 11 and 13. As the voltage on pin 6 goes down, the pulse width lengthens. This provides regulation of the 5V Supply (discussed in greater detail later). The two outputs of U5 are always equal widths but are 180 degrees out of phase with each other.

2F-16. During the time it takes C13 to charge up to 12V, the current through R18 provides a sense input to U5. This input causes the pulse width out of U5 to begin at a narrow width and slowly move outward to provide the Soft Start function.

2F-17. R22 must be adjusted to establish the 50 kHz fundamental frequency of the output at U5 pins 11 and 13. This is necessary for the other components in the supply to function correctly.

2F-18. Switching Transistor PCB

2F-19. The output of the ±HV Supply and the 50 kHz output of the Pulse Width Modulator both act as inputs to the Switching Transistor PCB. The +HV enters the PCB on J18 pin 1 and goes to the collector of one of the switching transistors, Q1. The -HV enters on pin 5 and goes to the emitter of the other switching transistor Q2.

2F-20. The complementary 50 kHz outputs of the Pulse Width Modulator enter the PCB on J18 pins 13 and 15 to provide the drive for Q5 and Q6. As these transistors turn off and on, their outputs work through coupling transformers T2 and T3 to turn Q1 and Q2 on and off (180 out of phase with each other) for the duration of the pulses provided by the Pulse Width Modulator.

2F-21. The transistors Q1 and Q2 are connected together and provide the active drive to one end of the primary winding of the power transformer on the PS Rectifier PCB. The other end of the power transformer primary goes to the power supply neutral through the single turn primary of the Current Sense transformer T1. Capacitor C2 prevents any DC component in this current path.

2F-22. Transistors Q3 and Q4 provide the Turn Off Circuit function by actively depleting the emitter-base junction at turn off time. If these transistors are not operating, a significant increase in the turn off fall time of the outputs of Q1 and Q2 occurs which causes the power being dissipated by these transistors to rise. This decreases the overall efficiency of the supply and shortens the life span of Q1 and Q2.

2F-23. The output of the Current Sense transformer is a positive and negative going train of pulses at 50 kHz. These pulses have an amplitude that is proportional to the current in the primary of the Power Transformer, a width equal to the width of the output pulses of the Pulse Width Modulator and a polarity equal to the direction of current in the primary. The output of Q1 produces the negative going pulse and the output of Q2 produces the positive pulse. This wave form can be monitored over on the Power Supply Control PCB at TP1.

2F-24. 50 kHz Power Transformer

2F-25. Refer to the P/S Rectifier Schematic. The 50 kHz Power Transformer has 4 secondaries. Its small physical size is due to the high frequency it is designed to run at. A transformer of similar power capabilities designed for 60 Hz would be many times larger.

2F-26. Supply Rectifiers

2F-27. Notice how each of the output voltages has its own individual rectifier and filter. Since all supplies originate from secondary windings that share the same transformer core and primary winding, they all respond to pulse width modulation of the primary equally. Because the Pulse Width Modulator senses and regulates the 5V supply output (discussed in detail later), these outputs are all slaved to the 5V supply output.

2F-28. +5V Sense and Regulation

2F-29. Notice how the 5V Sense High/Low outputs originate ahead of the power supply filter. Now, refer to the Power Supply Control schematic and note how these same signals (5V SENSE and 5V RETURN) act as inputs to a filter circuit which reacts to load changes faster than sensing at the load itself. The output of this circuit acts as an input to the non-inverting input of the Error Amp U3. The other input to U3 is a reference voltage that can be adjusted by R50 (5 VOLT ADJ). Since U3 acts like a comparator, its output will swing up and down as the non-inverting input goes above and below the reference voltage.

2F-30. CR11 diode couples the output of U3 to the input of the Pulse Width Modulator U5 (pin 6). As the output of U3 changes, U5 regulates the pulse width of its

drive signal outputs on a pulse to pulse basis to keep the 5V supply output in regulation. Since line regulation is provided with respect to the 5V supply, all other output voltages track the 5V output.

2F-31. Because there is no remote sensing, load regulation is dependent on distribution impedances. The power supply must not be operated without a minimum load of about 10% on all sources. When it is unplugged from the controller, an interlock prevents operation.

2F-32. FAULT PROTECTION

2F-33. The power supply will shut down in response to three different fault conditions; primary circuit overcurrent, +5V over voltage, and high temperature. Detection of one (or more) of these faults will trigger a monostable circuit consisting of U1, R56-58, CR7,CR8, C23 and C38. The output of this circuit remains active for about one second. As long as it is active, the modulator output will be held off via the soft-start circuit. If the cause of the fault no longer exists when the monostable active period is complete (i.e., the modulator inhibit input is not active low),the power supply will attempt to restart automatically invoking a soft start.

2F-34. LOW LINE SHUTDOWN

2F-35. In order to avoid excessive ripple on the supplies (incurred by dropping out of regulation at low line voltages), the power supply is held off (shut down) until the line voltage is sufficiently high. The AC line sense filter is divided by R29, R30, and C15 and used as an input to a comparator (U2 pin 10). Shutdown occurs at a lower line voltage than turn-on to avoid oscillation.

2F-36. OVERCURRENT PROTECTION

2F-37. Overcurrent protection limits the total power dissipation of the switching transistors. Refer to the Power Supply Control schematic. Connector P18 pin-12 is the output of the current sense transformer on the Switching Transistor PCB. This putput establishes a voltage level on the integrator C16/R46 that is proportional to the current being drawn by the Power Transformer. Both the threshold voltage and the voltage on C16 are compared by the Over Current comparator U1. If the threshold is exceeded, the low output of U1 causes a shutdown by bringing pin-15 of U5 low.

2F-38. OVERVOLTAGE PROTECTION

2F-39. U1 pin-10 input is proportional to the 5V supply voltage, from P14 pin-27. If the 5V supply voltage exceeds the threshold established by R9 and R10, the output of U1 pin-13 goes low and causes U5 to shut down the supply by bringing U5 pin-15 low.

2F-40. FAN

2F-41. The fan electronics are in a separate module that has the -12V supply voltage as an input. This module provides three phase drive power for the fan that makes the fan speed independent of line frequency. This is done to allow the supply to run on a variety of line frequencies.

2F-42. BATTERY BACKUP

2F-43. Battery Backup Supply

2F-44. As shown on Figure 2F-1, the Battery Backup Power Supply receives input power from the 6V Battery and the 12V Supply. Each of these power sources feeds the Battery Backup Power Supply through a diode. As long as the 12V supply is up and running it reverse biases the diode for the 6V Battery and acts as the power source for the supply. If it drops below 6V (nominal) the Battery Backup Supply draws power from the Battery.

NOTE

The 6V Battery has a fuse which protects it from damage when an external battery of greater than 6V is connected. If this fuse (F1, 5A) blows, the Battery Backup Supply will not work off the internal Battery until it is replaced.

2F-45. Refer to the P/S Rectifier Schematic. The input for the supply is through R6. Notice how both sources meet here and how power from either one can flow through R6, through the primary of T4, and through Q3 to ground when Q3 is on. IC U2 functions as a switching regulator for the +12VB supply by turning Q3 on and off as follows:

1. Since an internal oscillator controls the basic rate of operation for U2, we can begin this discussion with U2 providing a current path through R7 to the base Q3 which turns Q3 on. As soon as Q3 is on, current begins to ramp upwards through R6 and the primary of T4. At approximately 8A the voltage drop across R6 exceeds the current sense point of U2, across pins 13 and 14.

2. At that time, U2 opens the bias path for the emitter base current that turned Q3 on. As soon as Q3 turns off, the primary of T4, acting as an inductor, causes the voltage on the collector of Q3 to rise. This voltage causes a current flow through CR10 which begins to charge C19.

3. Pin 10 of U2 monitors the rising voltage on C19 through a divider consisting of R20, R21 and R23 (the +12VB Adjustment). As soon as this voltage

reaches +12V, U2 turns Q3 on again to repeat the process. Note that the time it takes to charge C19 is load dependent and that as the load increases, the rate at which U2 switches Q3 on and off increases.

2F-46. IC U2 controls Q2 directly causing Q2 to act as a series pass regulator for the +5VB Supply. Pin 7 of U2 is the 5VB sense, and a reference voltage for U2 pin-6 comes from the junction of R5 and R4.

2F-47. The transformer action of T4 provides a negative source voltage for the -5V regulator U4. CR11 provides rectification of the output of T4.

2F-48. Battery Charger

2F-49. IC U3 is a linear voltage regulator which is used in conjunction with Q1 to provide a charging source for the battery when ac power is present. This charging circuit is current limited to about 250 milliamps. Resistor R25 provides adjustment of battery charging voltage.

2F-50. Low Battery Dropout

2F-51. IC U1 monitors the battery voltage and opens K1 when the battery voltage drops below 5.5V. This disables the Battery Backup Supply before the battery is fully discharged so that there is still some capacity to maintain the time of day circuitry. Switch S1 is used to manually disable the battery backup feature when it is not necessary. Note that if this circuit is always enabled, the battery will discharge each time ac power is shut off. This will reduce battery life. It also reduces the capacity of the battery to backup the E-disk.

2F-52. STATUS LINES

2F-53. Three bus lines can be set by the power supply:

1. ACOK set false (low) when the line power is lost for more than 30 ms. Also set false if the ABORT switch is enabled and closed.

2. DCOK set true (high) about 1/2 second after the power switch is turned on and set false (low) with any power shutdown command.

3. HALT controlled through a debounce circuit by connecting a switch to a pin on the remote connector on the rear panel.

2F-54. REMOTE CONNECTOR

2F-55. The remote connector provides the following features:

1. ABORT switch enable and remote operation

2. HALT control

3. RESTART switch enable and remote operation

4. External Battery

5. LED #6 and LED #7 which can be set under software control.

6. Remote operation of battery backup disable

Section 2G
Clock Module

2G-1. INTRODUCTION

2G-2. The 1720A Clock Module resides on the DMA Floppy Interface Module PCB and does not occupy a separate slot in the mother board. The CPU Module uses the 1720A CRU Bus to communicate with the Clock Module. The clock is provided with battery back up from a 6 volt battery during power off and will operate normally for about 2 to 3 months. It will keep track of time through the year 2004 but does not automatically take leap years into account and must be manually reset each leap year.

2G-3. CRU INTERFACE

2G-4. As mentioned in the Introduction, the CPU Module uses the CRU Bus to communicate with the Clock Module. This usage of the CRU Bus involves 15 bits, each with a specific CRU address. The CPU Module can write (set/reset) or read each bit. All operations involving the Clock Module are carried out via these 15 bits. Refer to the DMA Floppy I/F Clock schematic. Notice that the signal CRUSLCT- goes active (low) when the address 17EO (Hex) appears on the Address Bus. This signal remains low throughout the address range of 17EO to 17FF and goes to the Clock Module to enable addressing of the 15 bits which occupy this range. The actual addressing of the individual bits is done by the four least significant CRU address bits (A01 to A04).

2G-5. Bit Assignments

2G-6. Each of the 15 bits has two meanings to the CPU Module, one for an output (CROUT) operation and one for an input (CRIN) operation. Table 2G-1 shows the bit assignments for each bit.

2G-7. Clock Registers

2G-8. As shown in Table 2G-1, bits 0 through 3 function as digit select lines to the clock. Refer to the schematic again and notice that U12, the clock, has these lines (S0, S1, S2, S3) as inputs. The CPU Module can select 1 of 10 BCD digits (clock registers) for reading by setting these lines to the appropriate bit pattern. Table 2G-2 shows how digit selection is accomplished.

2G-9. OPERATIONAL SEQUENCES

2G-10. Overview

2G-11. Once the 1720A operating system has received the correct time from the user, it sets this time into the clock and sets the valid time flag (TVAL) to indicate that the clock has been set. From then on, as long as the battery back up is maintained, the operating system reads the correct time from the clock on each bootup. If for some reason the battery voltage drops to a value that would destroy the time information, the valid time flag (TVAL) is cleared by the hardware. Then the next time the operating system checks this flag, it will assume invalid data and return a relative time of zero which, when added to the reference date of 1-1-72, will give 00-00 1-1-72. In addition, a year increment bit (YINC) is set and used by the operating system to keep track of year rollover, as explained later.

2G-12. Setting the Time

2G-13. To set any of the five time periods (seconds, minutes, hours, days, months), the CPU Module sets the binary code for that digit into S0 through S3. Then it toggles (set high then low) the INCR bit. Following this, it reads the digit by setting the READ bit high and reading the D0 through D3 bits. It compares this value to the value needed and repeats the process until the digit is set to the correct value. Refer to the schematic again. Within the Clock Module hardware this sequence takes place as follows:

Table 2G-1. Bit Assignments

Bit #	Output	Input
0	S0 (digit select)	D0 (BCD digit)
1	S1 (digit select)	D1 (BCD digit)
2	S2 (digit select)	D2 (BCD digit)
3	S3 (digit select)	D3 (BCD digit)
4	INCR	Not used
5	Not used	Not used
6	READ	Not used
7	Not used	Not used
8	YR0 (year information)	YR0
9	YR1 (year information)	YR1
10	YR2 (year information)	YR2
11	YR3 (year information)	YR3
12	YR4 (year information)	YR4
13	YINC (year increment bit)	YINC
14	TVAL (valid time flag)	TVAL
15	Not used	ID (identification)

Table 2G-2. Clock Register Assignments

TRUTH TABLE	REGISTER (DIGIT)	DATA BUS
S3 S2 S1 S0	SELECTED	D3 D2 D1 D0
0 0 0 0	None	1 1 1 1
0 0 0 1	None	1 1 1 1
0 0 1 0	Seconds Units	BCD
0 0 1 1	Seconds Tens	BCD
0 1 0 0	Minutes Units	BCD
0 1 0 1	Minutes Tens	BCD
0 1 1 0	Hours Units	BCD
0 1 1 1	Hours Tens = 1 AM	1 0 1 0
0 1 1 1	Hours Tens = 0 AM	1 0 1 1
0 1 1 1	Hours Tens = 1 PM	1 1 1 0
0 1 1 1	Hours Tens = 0 PM	1 1 1 1
1 0 0 0	Days Units	BCD
1 0 0 1	Days Tens = 0	1 1 1 1
1 0 0 1	Days Tens = Not 0	BCD
1 0 1 0	Month Units	BCD
1 0 1 1	Month Tens = 0	1 1 1 1
1 0 1 1	Month Tens = 1	0 0 0 1
1 1 0 0	None	1 1 1 1
1 1 0 1	None	1 1 1 1
1 1 1 0	None	1 1 1 1
1 1 1 1	None	1 1 1 1

1. Bits 0 through 3 (digit select) are set one at a time by placing the bit address on the Address Bus and initiating a CRU output sequence:

   a. CRUSLCT goes active (low).

   b. CROUT is made high or low as necessary by the CPU Module.

   c. CRCLK goes active (low pulse).

   d. U20 (D-type flip-flop) latches and holds the state of CROUT.

   e. The output of U20 acts as the data input to the two addressable 8-bit latches U11 and U1.

   f. A01 through A03 address a specific latch within both U11 and U1 (Q0-Q3).

   g. Pin 10 of U14 (1-of-4 decoder) goes active (low pulse) because A04 is low on pin 13 and CRCLK is a high pulse on pin 14. This low enables U11 and sets the addressed latch to the state of CROUT.

2. The INCR bit is toggled by the same process to increment the clock register that was addressed by bits 0 through 3.

3. The value of the addressed register is read by the CPU as follows:

   a. The BCD value of the register addressed previously during the CRU output operation is on the D0 through D3 outputs of the clock. These lines act as inputs to U13 (8-channel data selector).

   b. The CPU Module places the bit addresses for the bits 0 to 3 one at a time on the Address Bus and does a CRU input operation for each one.

      1. A4 is set low. This drives pin 4 of U14 low which enables U13.

      2. The address on A01 through A03 selects which of the D0 through D3 outputs of the clock are output to the CRIN line which goes to the CPU Module.

4. If the CPU Module finds that the value of the digit is not correct, it repeats the incrementing process until the value is correct.

2G-14. Setting the Year

2G-15. The operating system sets the year to the value given to it by the user into the Clock Module. To do this the CPU Module sets the Q0 through Q4 latches in U1 to the appropriate states. This information is available from then on as an output of U2. Notice that if A04 is set to a 1, U2 instead of U13 is enabled by the output of U14. The sequence within the Clock Module hardware is as follows:

1. Bits 8 through 12 (year information) are set one at a time by placing the bit address on the Address Bus and initiating a CRU output sequence:

a. CRUSLCT– goes active (low) upon address recognition.

b. CROUT is made high or low as necessary by the CPU Module.

c. CRCLK– goes active (low pulse).

d. U20 (D-type flip-flop) latches and holds the state of CROUT.

e. The output of U20 acts as the data input to the two addressable 8-bit latches U11 and U1.

f. A01 through A03 address a specific latch within both U11 and U1 (Q0-Q3).

g. Pin 11 of U14 (1-of-4 decoder) goes active (low pulse) because A04 is high on pin 13, and CRCLK is a high pulse on pin 14. This low enables U1 and sets the addressed latch to the state of CROUT.

2G-16. Checking for Valid Time

2G-17. When the operating system sets the time it also sets the Q6 output of U1 (TVAL) to a 1 (using the CRU output sequence described in Setting The Year). A low voltage monitor circuit consisting of U3, CR1 and associated components generates a clear signal to pin 2 or U1 upon power up if the battery voltage has dropped below the minimum allowable value. This resets the TVAL bit (Q6) to zero. The CPU can read the state of this bit from U2 (bit 14) and know if the time is valid.

2G-18. Checking for Year Rollover

2G-19. On July 1, the operating system sets YINC (bit 13 or Q5 of U1) to a 1 using the same CRU output sequence described in Setting The Year. Then, every time the 1720A is initialized, it tests this bit. If the month is January through June and YINC is still set then it knows that the 1720A has not been turned on previously in the new year, so it increments the year and sets YINC to 0. But, if the operating system finds YINC at 0, it knows that the preceeding procedure has already been done and it leaves YINC alone until July 1. This algorithm makes the assumption that the controller will be powered on at least once every 6 months.

2G-20. Reading the Time

2G-21. The CPU Module can read the time in months, days, hours, minutes and seconds, by following the read sequence outlined in Setting The Time. It can read the year by reading the state of the latches in U1 which act as data inputs to U2. The latches are read in the following sequence:

1. The CPU Module places the bit addresses for the bits 8 to 12 one at a time, on the Address Bus.

2. It does a CRU input operation for each addressed bit.

   a. A4 is set high. This makes pin 5 of U14 low which enables U2.

   b. The address on A01 through A03 selects which of the data inputs to U2 (bits 8 to 12) is output to the CRIN line to the CPU Module.

Section 2H
Optional Electronic Disk

2H-1. INTRODUCTION

2H-2. The optional E-Disk provides the 1720A with 64K words of memory which is word addressable via the memory mapped I/O process. This module has an auto-increment capability for its internal address register to provide faster throughput for a block of data. The 1720A can have up to two E-Disk Modules Installed.

2H-3. The E-Disk Module has three 8-bit registers through which the CPU Module controls all read and write operations. Table 2H-1 gives the address assignments for each of the two boards and Table 2H-2 gives information about the individual registers.

2H-4. OPERATIONAL SEQUENCES

NOTE

The address examples in the following paragraphs are for Board #1.

2H-5. Write Operation

2H-6. The CPU Module can store data in the E-Disk Module. The paragraphs that follow describe the necessary steps.

2H-7. First the CPU Module executes a memory mapped I/O Operation to send the storage address to the E-Disk. In this process, the CPU Module does a memory write operation, placing the address of the E-Disk Address Register (F5C0) onto the 1720A Address Bus and placing the memory address at which it wishes to store the data byte onto the 1720A Data Bus.

2H-8. Following this, the CPU Module executes a Memory Mapped I/O Operation to send the data to be stored to the E-Disk Module. It does this with a memory write operation, placing the address of the E-Disk Data Register (F5C4) onto the 1720A Address Bus and placing the data word it wishes to store onto the 1720A Data Bus.

2H-9. If there is another byte of data to be stored in the same block of continuous addresses within the E-Disk, the CPU module repeats the second step only. It can do this because the E-Disk automatically increments the address within its address register after each operation. This process continues until the CPU changes the contents of the address register with another Memory Mapped I/O Operation.

2H-10. Read Operation

2H-11. The CPU Module can read information from the E-Disk Module. The paragraphs that follow describe the necessary steps.

Table 2H-1. Electronic Disk Address Assignments

BOARD #	ADDRESS ASSIGNMENT
Board #1	F5C0 to F5C7 (Hex)
Board #2	F5C8 to F5CF (Hex)

Table 2H-2. Register Assignments

Reg.	Address Hex (BD# 1)	Read/Write	Name
1	F5C0	Write	Address
2	F5C4	Read/Write	Data
3	F5C6	Read/Write	STATUS/CONTROL

NOTE: In Reg. #3, on a status read, Bit 15 = Parity Error. On a Control write, Bit 15 = Parity Error INTENABLE.

2H-12. First the CPU Module sends the address from which data is to be read to the E-Disk with a Memory Mapped I/O operation. It does this by doing a memory write operation, placing the address of the E-Disk Address register (F5C0) onto the 1720A Address Bus and placing the desired E-Disk memory address onto the 1720A Data Bus.

2H-13. Following this, the CPU Module reads the data with another Memory Mapped I/O Operation. To do this, it does a memory read operation, placing the address of the E-Disk Data Register onto the 1720A Address Bus.

2H-14. If there is another byte the CPU wishes to read from the next contiguous memory location, it repeats the second step only. The E-Disk automatically increments its address register after each operation.

2H-15. ADDRESS RECOGNITION

2H-16. Refer to the Electronic Disk Schematic to locate specific signals and components mentioned in this description. The Address Recognition and Register Decode circuits work together whenever the CPU accesses an E-Disk register. The Address Recognition circuit decodes 1720A Address Bus bits AD3 through AD15 to enable the Register Decode Circuit. The Register Decoder decodes bits AD1 and AD2 to select one of the registers in the module. The Register Decoder also decodes address bits from the Address Register and Multiplexer to produce the RAS (Row Address Strobes).

2H-17. In addition to enabling the Register Decoder, the output of the Address Recognition circuit (U40, pin-12) produces the ADACK on the 1720A Control Bus and gates BUSWR- to the Data Buffers to establish the direction of data flow. If BISWR- is low, the Data Buffers act as receivers from the 1720A Data Bus. If BUSWR- is high, the Data Buffers act as drivers to the 1720A Data Bus.

2H-18. MEMORY ORGANIZATION

2H-19. The organization of the E-Disk memory is shown in Figure 2H-1. The two banks (Bank 0 and Bank 1) that make up the memory each consist of sixteen 32,768 X 1-bit dynamic RAMs for data storage and oneextra 32,768 X 1-bit dynamic RAM for parity storage. The RAMs in both banks have parallel address lines, however, as explained later, not all of the ICs accept a given address. Each of the 16 RAMs that make up a given memory bank has one of the data lines from the Data Bus as an input/output and the extra RAM has the parity bit. Therefore, each bank can hold 32K words of data, giving a total capacity of 64K words. Note that the parity bit goes to and from the Parity Circuit and is not a part of the Data Bus (DB).

2H-20. MEMORY ADDRESSING

2H-21. The CPU sends the address for a memory access to the Electronic Disk address register via the 1720A Data Bus. The following sequence of events takes place within the module:

1. In response to both the address on the 1720A Address Bus and to the low state of the BUSWR- signal from the 1720A Control Bus, the Module latches the 16-bit address from the 1720A Data Bus into the Address Register and Multiplexer (U8, U16, U9, U17).

2. The AD0 through AD13 outputs of the counter/latches act as inputs to the address multiplexer U4, and the AD14 and AD15 outputs go to the Register Decoder which decodes them into either RAS0 and RAS1 (Bank1), or RAS2 and RAS3 (Bank2), depending upon which memory bank the address falls into.

2H-22. MEMORY DATA TRANSFER

2H-23. As soon as the row address process is finished, the CPU does either a memory write or read to the Electronic Disk Data Register via the 1720A Data Bus. The CPU does this either to store or retrieve data at the address it sent in the previous step. The paragraphs that follow describe the process that takes place within the E-Disk.

2H-24. The Data Register Select output of the Register Decode block (U2 pin 6) goes active (high). (Note that the Data Buffer is a receiver if this is a write operation and a driver if this is a read operation. This status is controlled by the state of BUSWR-. BUSWR- also controls the state of the WRITE input to the memory ICs.) The state of RWE the RAS enable at U2, pin-15, and the CAS- output of the RAS-CAS Generator (U22, pin-6) are all coordinated by the RAS-CAS Generator which begins the process upon the assertion of Data Register Select (U2, pin-6). Notice that the output of the address multiplexer U4 can be either AD0 through AD6, or it can be AD7 through AD13, depending upon the state of its RWE input:

1. First RWE goes low to gate AD7 through AD13 out of U4 at the same time that the RAS enable to U2, pin-15 is active. This gates the row address into the memory bank that receives the RAS strobes.

2. Next, RWE goes high to gate AD0 through AD6 out of U4, at the same time that CAS- goes active. This gates the column address into the memory chips.

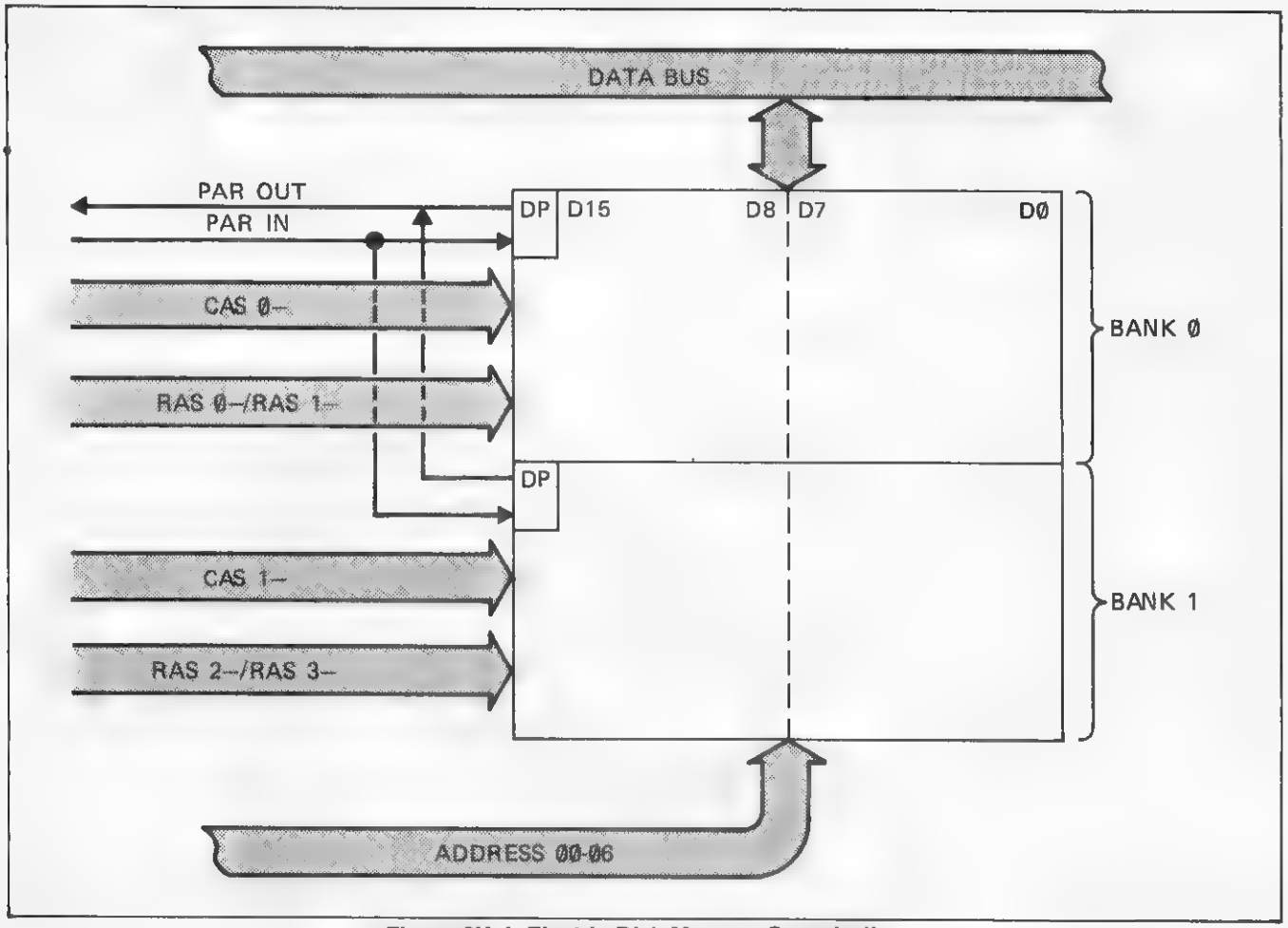


Figure 2H-1. Electric Disk Memory Organization

2H-25. Within the memory array, the ICs in the bank selected by the RAS strobes now contain the full 14-bit address (plus the correct RAS– strobe) necessary to access one of the possible 32K locations within that bank and actually begin the data transfer to or from the data bus.

2H-26. The actual data transfer takes place on the leading edge of CAS–, after the column address has been gated into the memory. The direction of transfer depends on the state of the WRITE input (determined by the state of BUSWR–). If WRITE is high the memory ICs store the data word from the data bus, and if it is low, they place the stored word onto the data bus.

2H-27. The Address Increment Control output, U72 pin-8, clocks the counter/latch ICs in the Address Register and Multiplexer to increment the address in the Address Register at the end of the operation.

2H-28. PARITY

2H-29. Refer to Figure 2H-2. The Parity Circuitry consists of ICs U25 and U33. They generate a parity bit during a write operation by making the PW line either high or low depending on the total number of high bits in the data word (high for even and low for odd). This produces an odd number of high bits in each memory location (including the parity bit). During a read operation, both the data word and the parity bit act as inputs to U25 and U33. U25 pin-5, goes high if there is not an odd number of high bits presented. This high output can produce an interrupt to the CPU Module if the CPU has enabled the interrupt (see Status/Control Register).

2H-30. MEMORY REFRESH

2H-31. The memory refresh description in the Memory Module theory of operation explains the need for refresh when using dynamic RAM ICs. It also explains how the refresh must be accomplished with RAS– only cycles during 2 ms time intervals. In the E-Disk Module, the Refresh Arbiter, Refresh Timer, and the Sync flip-flops all work together to perform the refresh of the memory ICs. They do this in two modes, battery back-up and normal, as explained in the following paragraphs.

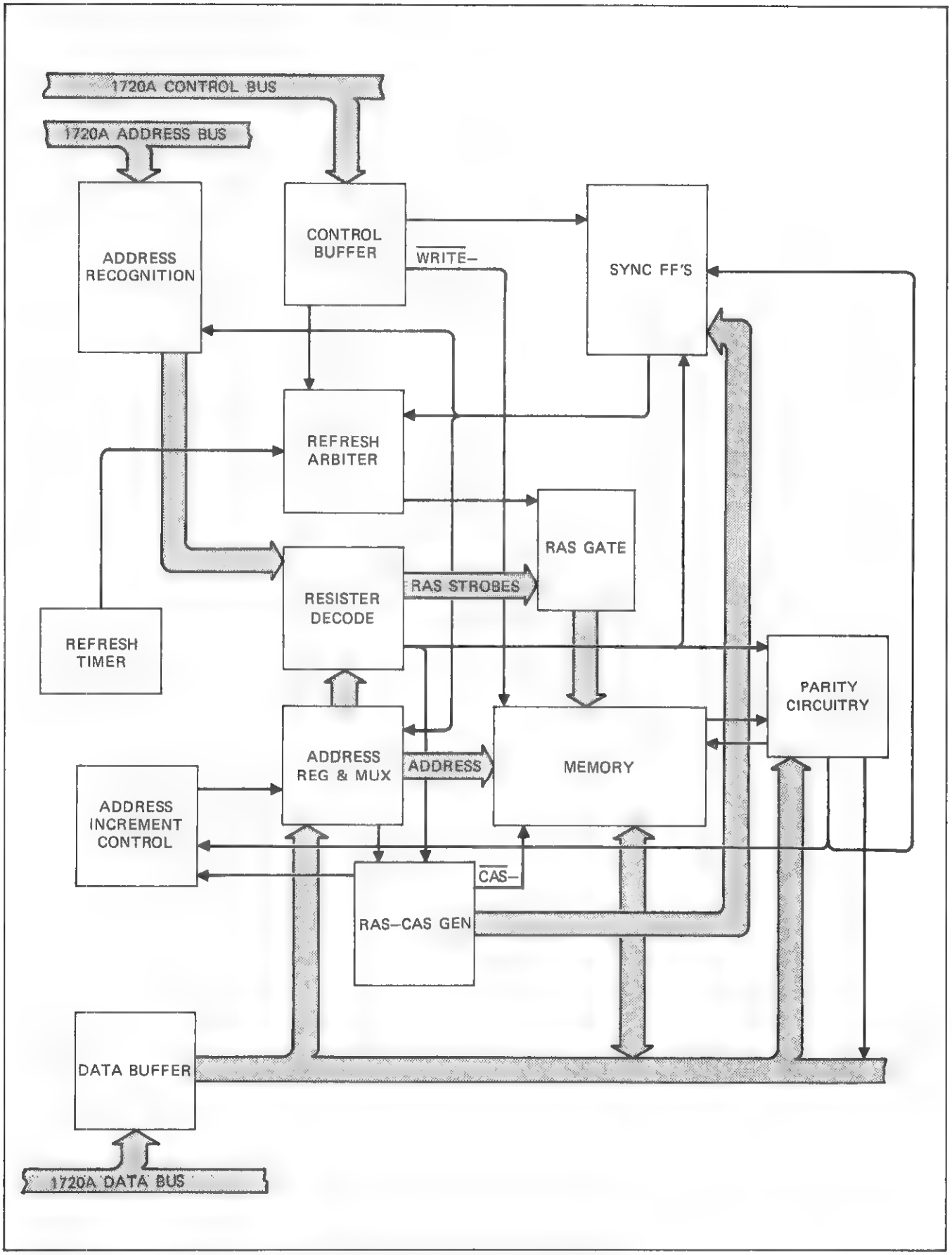


Figure 2H-2. Electronic Disk Block Diagram

2H-32. Normal refreshing occurs each time U31 pin-9, goes low. This low enables all four RAS outputs from the RAS Gate. The Refresh Arbiter produces this output each time the REFRQ output of the Refresh Timer (U14 pin-9) goes active (every 12 us) provided that the following conditions are met:

1. The system is not in battery back up (DCOK high).

2. The Module is not in the middle of a memory cycle (looks at the RAS flip-flop output).

3. The signal RINT– is not in the middle of the active low pulse. If this is the case, it will wait until the next RINT– and produce the output coincedent with the leading edge of RINT–.

4. The Refresh Arbiter circuit also eliminates certain undefined states in the flip-flop outputs from occurring as a result of the Refresh Timer being completely asynchronous with the system clock. These states, if they do occur, are not passed on to the memory chips.

2H-33. Each time the low pulse out of U31 pin-9 in the Refresh Arbiter circuit enables all four of the RAS outputs of the RAS Gate block, a refresh of one row address in each bank occurs. This address is an output of the Address Register and Multiplexer (U4). U4 has a RE (Refresh Enable) input (pin 2) and a CNT (Count) (pin 1). Inside this IC there is a counter, the output of which appears on the 00– through 06– outputs whenever the RE input is active (high). This counter counts upward each time the CNT input goes low, which happens each time there is a refresh. It cycles through all 128 row addresses, over and over again. As a result, a different address receives the refresh each time a refresh cycle occurs. Because the memory ICs do not receive a CAS– strobe during the refresh cycle, they do not perform a read or write operation.

2H-34. During battery back up, the Refresh Arbiter disregards all other considerations and refreshes one of the 128 row addresses every 12 us when the Refresh Timer output goes active (U14, pin–9). Notice that the RE input to U4 stays high at this time due to the BAT Sync flip-flop (U23, pin–9). The Refresh Arbiter still increments the internal counter of U4 with the CNT input each time it does a refresh.

2H-35. STATUS/CONTROL REGISTER

2H-36. As shown in the register assignment in Table 2H-2, the Status/Control Register performs a control function on a memory mapped write and a status function on a memory mapped read. The following paragraphs discuss these two functions.

2H-37. During a control function, the CPU sets DI15 to a 1 and does a Memory Mapped I/O write to address F5C6. Inside the Electronic Memory Module, DI15 and the control/status enable output of the register decode block (U2, pin–7) removes the set input to the parity error flip-flop (U49, pin–10). This leaves U49, pin–8 free to change state when a parity error detection occurs. This happens when there is a one output from the parity checker (U25, pin 5) during a memory read. This causes the output at U65, pin–11 to place a low on U49, pin-12. the clock for this flip-flop comes from the row enable flip-flop at the end of the memory cycle, and its output at pin–8 goes high. Remember, if the CPU does not remove the direct set input at U49, pin–10, there can be no change of states to indicate parity errors.

2H-38. During a status function, the CPU Module does a memory mapped read of the address of the Control/Status Register (F5C6). Any high output from U49 pin–8 would pass through U55 pin–5 to –6 and appear on DI15 to indicate a parity error.

2H-39. BATTERY OPERATION

2H-40. When the 1720A goes into battery back-up, most of the circuits in this module no longer receive +5V from the system. Only the refresh circuits receive their power from the battery-derived +5V and remain in operation to preserve the memory contents. Refer to the refresh description.

2H-41. BOARD SELECT SWITCH

2H-42. Refer to Table 2H-1, Electronic Disk Address Assignments. The switch S1 establishes the range of addresses a given Module responds to. Table 2H-3 details the function of the 4 individual switches within S1.

Table 2H-3. Electronic Disk Board Select Switch

S1				BOARD
1	2	3	4	ADDRESS RANGE (Hex)
off	off	off	off	F5C0 to F5C7
off	off	on	on	F5C8 to F5CF

Section 2J

PROGRAMMER KEYBOARD, TOUCH-SENSITIVE DISPLAY, AND CRT DISPLAY ELECTRONICS

2J-1. PROGRAMMER KEYBOARD

2J-2. Refer to the Keyboard Schematic. The keys on the keyboard are set up to form a matrix. The signals R0 through R7, representing the rows of this matrix, can only become active (high) when both a given key is pressed and the column in which that key is located is scanned. The microprocessor, located on the Video Keyboard Module, scans the columns by placing the appropriate BCD code on the S0 through S3 inputs of the 1-of-10 decoder IC. As a result, the keyboard output code on the R0-R7 lines consists of a binary bit (from the column being scanned) corresponding to the row in which the depressed key is located. The microprocessor in the Video Keyboard Module receives this code and any signal resulting from a SHIFT or CONTROL key depression. Then the microprocessor uses a PROM program to output ASCII code for transmission to the 1720A CPU Module.

2J-3. In addition to producing the ASCII code, the microprocessor also initiates a one-shot output from the Video Keyboard Module. This pulse enters the keyboard on pin 2 of the connector and activates a solenoid to make a click sound. This provides audible feedback to the keyboard operator.

2J-4. The microprocessor also produces the signals required to light the Caps Lock and Page Mode LEDs. It does this if it receives the code from either of these two keys.

2J-5. TOUCH-SENSITIVE DISPLAY

2J-6. Refer to Figure 2J-1. As shown, the Touch-Sensitive Display consists of two sheets of mylar which have vacuum deposited gold on one side. Scribe lines in this gold coating form electrically isolated conductive bands. The rear sheet is scribed horizontally and bonded to an acrylic backing panel. The front sheet is separated from the rear sheet by a gasket and is scribed vertically. This creates a 10 by 6 switch matrix with normally open contacts.

2J-7. If one of these grid switches is closed by an operator's touch, the microprocessor on the Video Keyboard Module produces a special code for output to the 1720A CPU Module. This output is a binary number from 1 to 60 (with the eighth bit set to 1) that corresponds to the switch position that was touched.

2J-8. CRT DISPLAY ELECTRONICS

2J-9. Refer to Figure 2J-2. The CRT display electronics produce a free running horizontal sweep (left to right) that scans downward on successive sweep lines, doing a horizontal retrace at the end of each line. When it reaches the bottom of the screen it does a vertical retrace to the top of the screen and repeats the process. This is done by passing appropriate sweep ramps through yoke coils on the neck of the CRT.

2J-10. As shown on the block diagram, the Horizontal and Vertical Sync inputs from the Video Keyboard Module pass through amplifier and shaper circuits to the oscillators that produce the sweep. In the presence of proper sync signals, these oscillators become synchronized to the video input which is also produced by the Video Keyboard Module.

2J-11. In response to this video signal, the Video Ampl./Output circuit in the display electronics modulates the trace into a series of dots and spaces. The Video Keyboard Module causes these dots and spaces to occur at the proper intervals to make characters appear on the display.

2J-12. The horizontal sweep output goes to the High Voltage Supply as well as the horizontal yoke coil of the CRT. In the High Voltage Supply, the sweep passes

through the primary coil of a high voltage transformer. This transformer has two secondaries. One secondary produces high voltage and the other secondary produces filament voltage for the CRT. The high voltage output is rectifed by a diode to provide DC for the CRT anode. The filament voltage goes directly to the CRT.

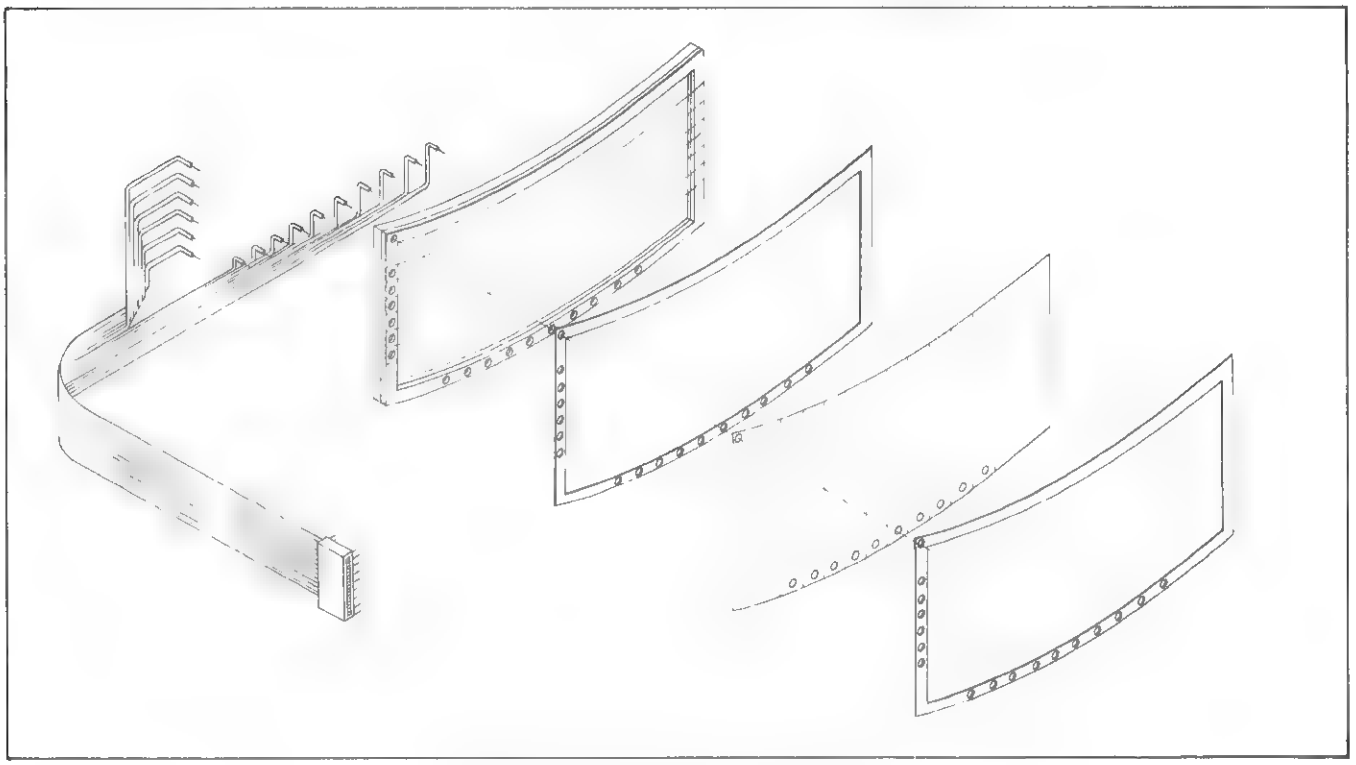


Figure 2J-1. Touch-Sensitive Display

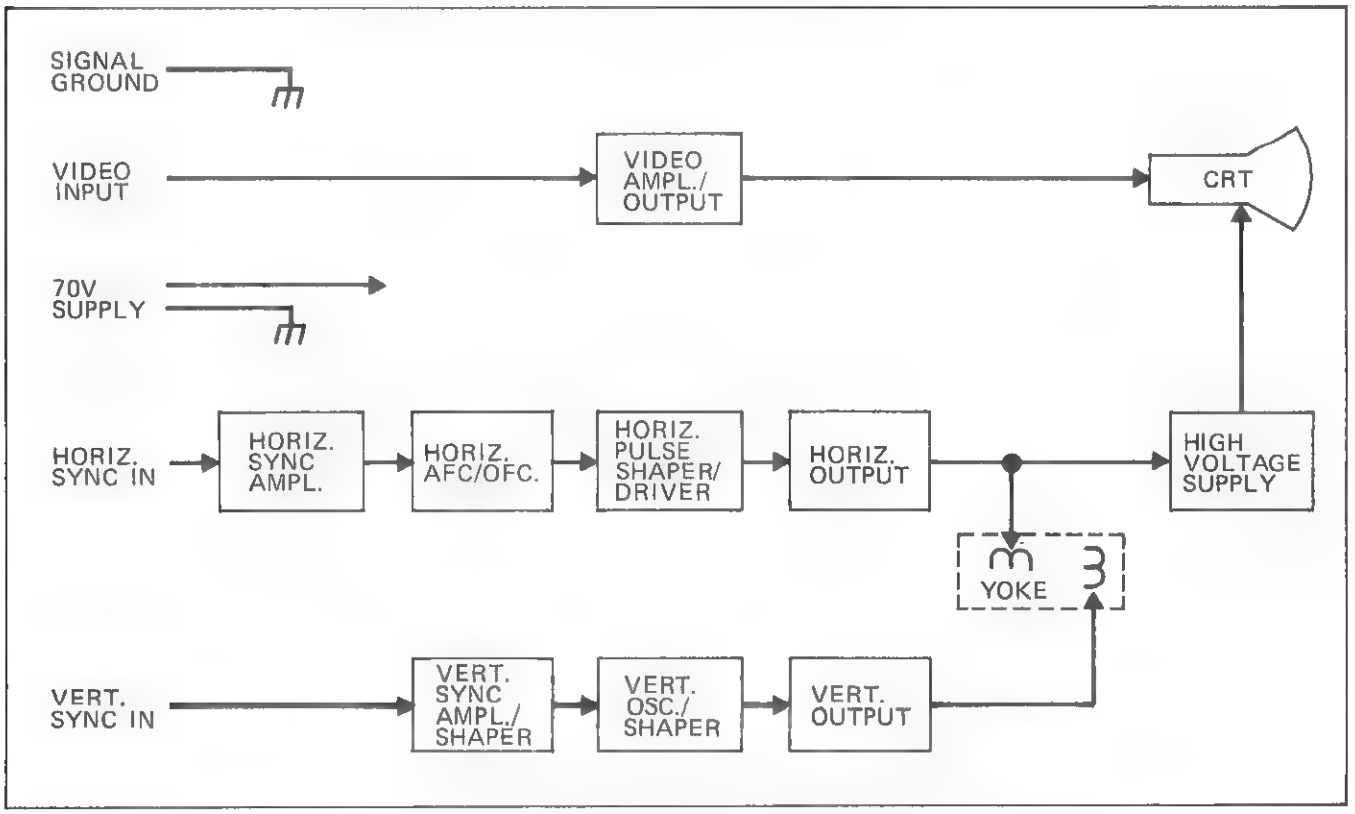


Figure 2J-2. CRT Electronics Block Diagram

Section 2K
Floppy Disk Drive Unit

2K-1. INTRODUCTION

2K-2. The Floppy Disk Drive Unit does the actual writing and reading of data to and from the floppy disk media. It does this under the direction and control of the DMA Floppy Module. This discussion covers both the drive unit and the track and sector format used on the media.

2K-3. THE DRIVE UNIT

2K-4. The Floppy Disk Drive Unit is fully self contained and requires no operator intervention during normal operation. It consists of a spindle drive system, a head loading and positioning system, and a read/write and erase system. Diskettes are inserted through the open front door. Media guides position the diskette laterally and up/down. A back stop ensures correct in/out positioning. Closing the front door activates the cone/clamp system. This system first centers the diskette then clamps it to the drive hub. The drive hub is driven at a constant speed of 300 rpm by a dc motor.

2K-5. In operation, the head load system loads the magnetic read/write head into contact with the recording medium. This is done by:

1. Referencing the diskette to a platen surface.
2. Referencing the head crown to the same platen surface as the diskette.
3. Providing a pressure pad which is loaded on the opposite side of the recording medium from the head with a force of 12 to 15 grams.

2K-6. A 4-phase stepper motor/cam assembly and associated electronic circuits positions the read/write head over the desired track. The positioner employs a 2-step movement to cause a 1-track linear movement.

2K-7. The drive has the following sensor systems:

1. A write protect sensor that disables the write electronics of the drive when a write protected diskette is inserted into the drive.
2. A Track 0 switch which senses when the read/write head is positioned over Track 0.
3. Index sensors, which consist of LED light sources and phototransistors that generate a digital pulse each time an index hole is detected.
4. A disk-present sensor.

2K-8. TRACK AND SECTOR FORMAT

2K-9. The 1720A must prerecord sector address information on the diskette before storing any information on it. This is done as a formatting process via a utility program before the disk is used by a user program. Each diskette has a single index hole which is used during this formatting process and for determining time-out (five revolutions without an address match). At the completion of the formatting, each of the tracks is divided into 10 sectors allowing data records to be stored under a track and sector address. These are not actual tracks (grooves) in the recording media. Instead, they are the places to which the read/write head positioner steps the head. The outermost track is track 00.

2K-10. Refer to Figure 2K-1. This simplified representation of the track and sector format shows the 10 physical sectors and the three outer tracks with the sectors numbered as they are addressed. Notice that the sectors are interleaved. This is done when the diskette is formatted by giving the sectors on each track an address in their ID field which differs from their physical location. In addition, the sectors are skewed four positions from track to track in order to compensate for the 25 ms step time.

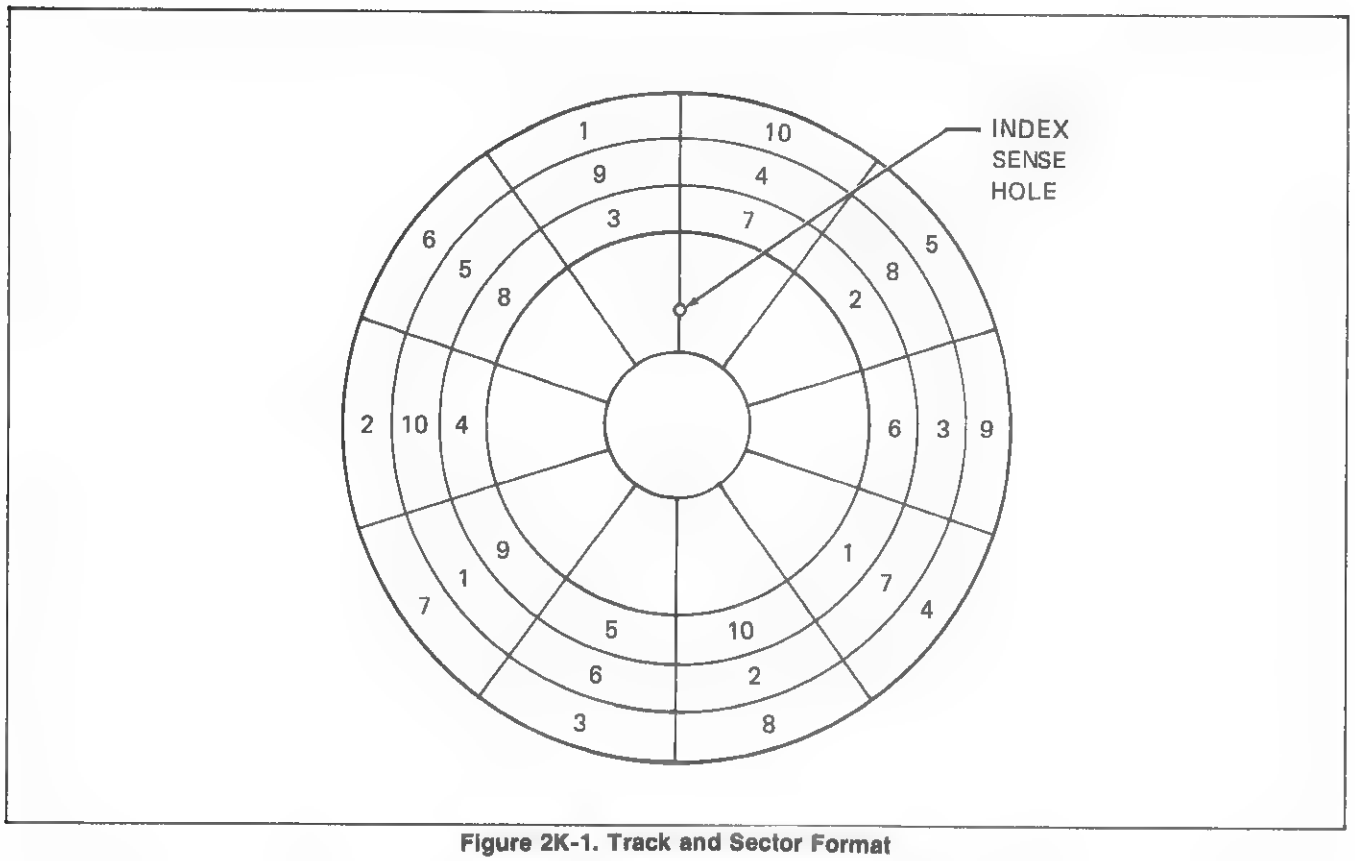
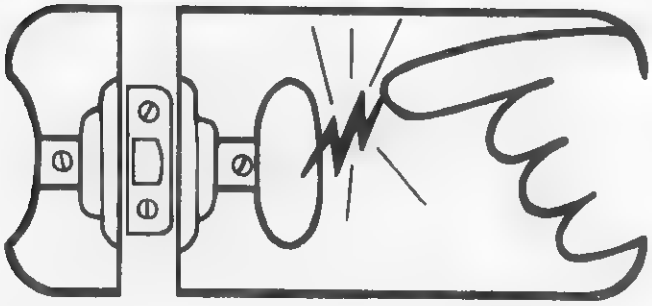


Figure 2K-1. Track and Sector Format

static awareness

A Message From

John Fluke Mfg. Co., Inc.

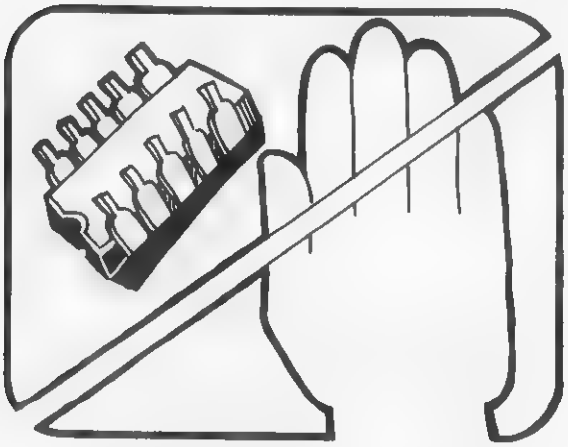


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

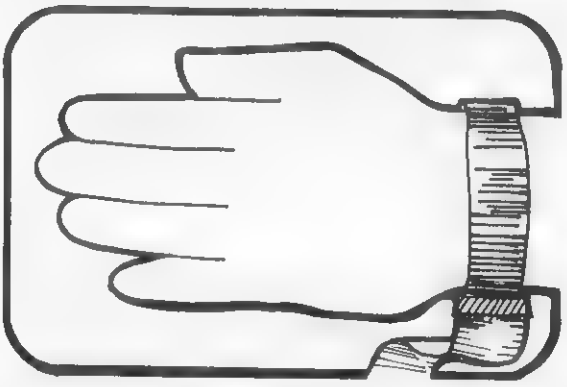
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗"

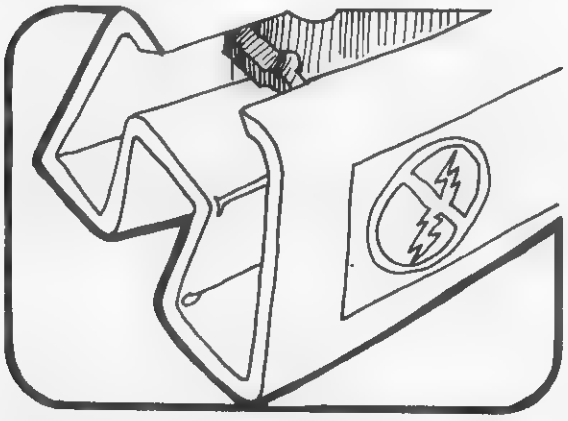
The following practices should be followed to minimize damage to S.S. devices.



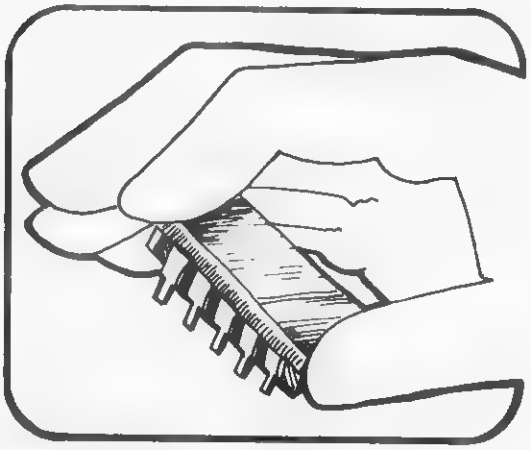
1. MINIMIZE HANDLING



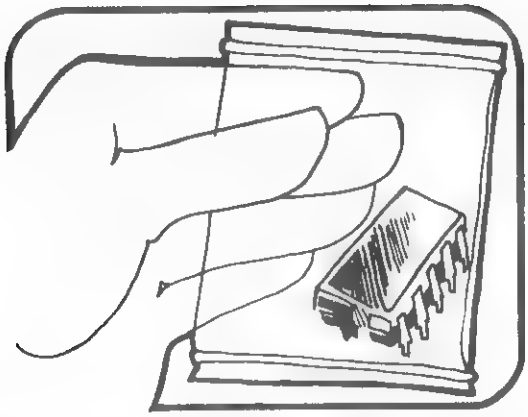
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



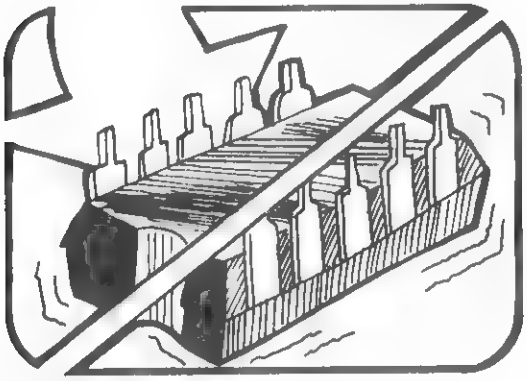
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



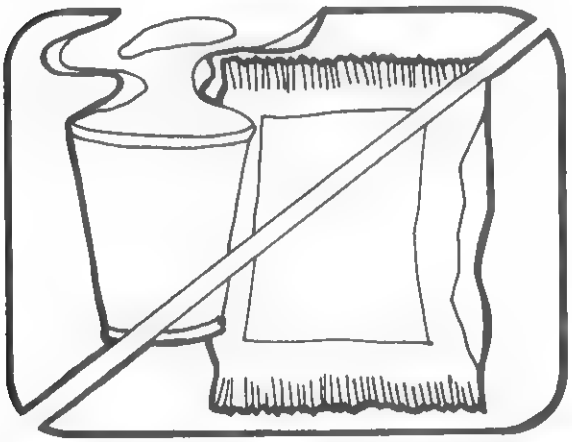
4. HANDLE S.S. DEVICES BY THE BODY



5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA

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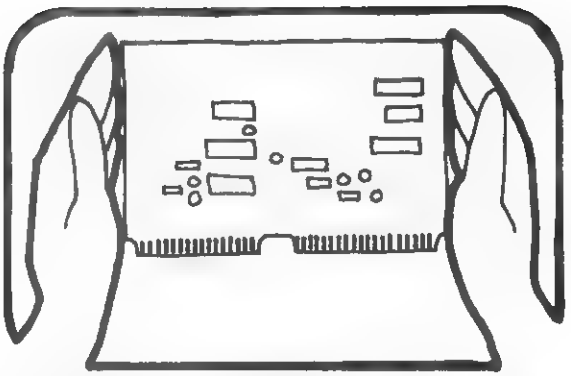
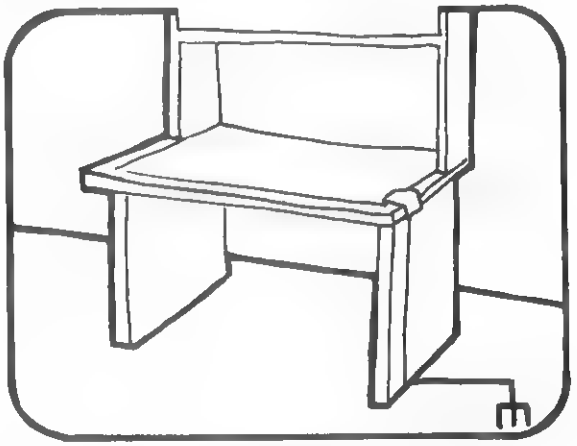
AND GENERAL DYNAMICS, POMONA DIV.

® Dow Chemical



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR USUALLY PROVIDES COMPLETE PROTECTION TO INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

Description	John Fluke Part No.	Price
6" x 8" Bag	453522	Per Current Parts Listing
8" x 12" Bag	453530	Per Current Parts Listing
16" x 24" Bag	453548	Per Current Parts Listing
12" x 15" Bag	454025	Per Current Parts Listing
Wrist Strap	571992	$7.00
30" x 60" x 60 Mil	RC-AS-1200	$22.00

J0089B-07U7810/SE EN Litho in U.S.A.

Section 3
Maintenance

3-1. INTRODUCTION

3-2. The 1720A Controller has a modular design that mimimizes down time by allowing the user to diagnose troubles down to a module level. The diagnostic procedure presented at the beginning of this section has two parts: the Live Box Procedure and the Dead Box Procedure. These procedures can usually narrow the failure down to one of the replaceable modules. The Assembly/Disassembly Procedures that follow the Live and Dead Box Procedures describe how to remove and replace the faulty module. In addition, the user can quickly determine if the software or the hardware is at fault in any given problem by running the Live Box Procedure. If the system goes through the Live Box Procedure without any failures, then the problem must be caused by the software. The final portion of this section is the Preventative Maintenance Program which details the periodic actions necessary to maintain optimum performance.

3-3. System problems fall into two general catagories:

1. Live-box failures, where the display still functions and the system can load a disk.

2. Dead-box failures, where the display is not usable, and/or the system cannot load a disk.

3-4. To begin troubleshooting a problem, you must decide which type of failure you are attempting to troubleshoot. The only function of the Dead-box Procedure is to arrive at a point where the Diagnostic Disk can be loaded so that you can run the Live Box Procedure. Therefore, if the display is functioning and you can load the Diagnostic Disk, you should start with the Live Box Procedure. If this is not the case, you should start with the Dead Box Procedure.

NOTE

The locations of the test points, adjustments, and components called for throughout this section are shown in Figure 6-2 unless otherwise indicated. This is a fold-out figure and is located in Section 6 for ease of reference.

3-5. REQUIRED EQUIPMENT

3-6. Table 3-1 lists the required equipment. If the equipment recommended is not available, then other equipment with equivalent specifications may be used.

3-7. LIVE BOX PROCEDURE

3-8. Introduction

3-9. This procedure uses the CVFY (Controller Verification) program from the Diagnostic Disk to identify the faulty module. This program verifies that each module in the 1720A is operating correctly. The assumption is made that all hardware problems will cause a failure of at least one of the tests made by CVFY or by one of the other tests at the end of the procedure. The complete Live Box Procedure, therefore, constitutes a total verification of the system performance.

3-10. The CVFY program is an assembly language program that is loaded via the Console Monitor. It is a structured program that makes calls to modular subprograms. It calls these subprograms one at a time by loading them from the Diagnostic Disk then executing them. They return their pass/fail data to CVFY upon completion.

Table 3-1. Required Equipment

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT	FUNCTION/COMMENTS
LIVE BOX PROCEDURE		
Dual Trace Oscilloscope	Tektronix 465B	
IEEE Interface Cable	Fluke #Y8001	Connect IEEE ports together
RS-232-C Null-modem*	Fluke #Y1705	Connect RS-232-C Ports Together
Diagnostic Disk*	Fluke #521419	Diagnostic Program
DEAD BOX PROCEDURE		
Halt Button*	Fluke #580589	
24 Pin IC Puller*	Fluke #572339	
Alignment Tool*	Fluke #572321	
HDT PROMs*	Fluke (Odd) #576314 (Even) #576322	
Alignment Disk*	Fluke #572313	
Display Alignment Gauge*	Fluke #535864	
Jumpers (2)		10 inch, alligator
Dual Trace Oscilloscope	Tektronix 465B	
DVM	Fluke 8020A	
Customer Maintenance Kit	Fluke #577791	
* Customer Maintenance Kit (contains all * items above)		
Note: If your system does not make use of the RS-232-C ports, you can omit the RS-232-C Cable requirement. The test (#7) will record an error which can be ignored.		

3-11. On completion, each subprogram either displays data that can isolate the area of the fault to the nearest replaceable module or displays PASSED. You should watch the Display while CVFY is running. The subprograms that test the various cursor and display functions only attempt the various operations and rely on you to check that the attempt was successful and to keep track of any discrepancies between what the Display says will happen and what actually does happen. As soon as all the subprograms are finished, CVFY prints a summary indicating which subprogram passed or failed. Refer to Figure 3-1. As discussed in the Live Box Procedure Steps that follow, you will use this summary to locate the faulty module.

3-12. Live Box Procedure Steps

3-13. Before using this procedure read the following notes:

1. In the Live Box Procedure that follows, the term "enter" means type the indicated word or words then press RETURN.

2. ** indicates an evaluation or action step that directs you to take action or to go to another step within the procedure.

3. Anytime you replace a component in the system, you must run the Live Box Procedure to have assurance that the system is fully operational.

4. Whenever you are asked to press a control character, such as CTRL C, hold the CTRL key down while you press the indicated key.

5. The term "normal configuration" means that the 1720A is set up to run normally. In particular:

   a. All PCBs are in place.

   b. Regular PROMs are installed.

   c. All Normal/Test switches are in Normal.

   d. All covers, wires and cables are in place.

   e. No test jumpers are in the system.

   f. All connectors are installed.

6. Before calling Fluke Service, if this procedure fails to locate the fault, please go over all the steps you made that led up to that point in the procedure.

TEST SUMMARY TABLE

TIMES PASSED = 6 TIMES FAILED = 9 TIMES CYCLED = 15

TEST 1	CPU INSTRUCTIONS	PASSED
TEST 2	MEMORY	PASSED
TEST 3	VIDEO	PASSED
TEST 4	FLOPPY	PASSED
TEST 5	CLOCK	FAILED
TEST 6	IEEE	PASSED
TEST 7	RS232	FAILED
TEST 8	ELECTRONIC DISK #1	MISSING
TEST 9	TOUCH SENSE	PASSED

Figure 3-1. Sample CVFY Summary

STEP A. INITIAL SET UP

1. Install IEEE Interface Cable between the two ports.

2. Install RS-232-C Null Modem Adapter between the two ports.

3. Insert the Diagnostic Disk into the Drive Unit.

4. Press RESTART button.

5. The 1720A now does a Self Test.

   a. 1720A Displays "SELF TEST" (flashing)

   b. 1720A Displays "LOADING" at the end of the Self Test.

   c. 1720A Displays:

   "COMMAND FILE ACTIVE" (for 1 second)

   "CVFY Time Date"

   ** If these messages do not appear, then go to the Dead Box Procedure.

   ** If these messages do appear, take no action; Step B is automatic.

STEP B. 1720A NOW LOADS CVFY

1. CVFY displays a menu and some instructions. Read the Display but take no action at this time. You'll notice that you may:

   a. Enter F for Final Test

   b. Enter A for Burn In

   c. Enter a test number to loop on an individual test, or enter a 0 to run all the tests.

2. This procedure assumes that you elect to run all tests (enter 0) but you should be aware of two things:

   a. Test 9 (Touch Sense) requires operator interaction.

   b. The contents of the optional Electronic Disk memory are overwritten by Test 8.

3. After you enter 0, CVFY gives you a chance to catalog the results on the line printer (yes/no). Enter NO so that the results appear only on the display.

STEP C. 1720A NOW RUNS CVFY

1. CVFY calls the subprograms one at a time.

2. CVFY compiles a summary of the results.

3. CVFY displays the Test Summary.

STEP D. INTERPRETING CVFY RESULTS

1. The 1720A performance as a system depends on the correct operation of various functions. The tests that make up the CVFY program are designed to isolate and verify the performance of these functions. Some of the replaceable modules of the 1720A perform more than one function. Functions, however, do not occupy more than one module. Therefore, in general, failure of a specific test calls for replacement of the affected module.

2. Table 3-2 presents the catagories of functions tested by CVFY and relates them to replaceable

modules. All you need do is to locate the particular function that is failing in your system by looking on the CVFY Sample Summary, and use Table 3-2 to find which module you need to replace.

CAUTION

Turn the power off and turn the E-Disk Battery Disable Switch to the DISABLE position before removing or inserting any PCB or connector.

NOTE

Any time you replace a faulty module, you must do this part of the Live Box Procedure again. This verifies that the system is fully operational

STEP E. VERIFICATION OF DISPLAY ALIGNMENT

You should be entering this step from Step D and have already determined that the major 1720A system elements are performing correctly. This step can also be done as a stand alone verification of the display alignment at any time.

1. Load the Diagnostic Disk into the Drive.
2. Press RESTART
3. Wait while the 1720A loads the Diagnostic.
4. As soon as the CVFY Menu appears, press CTRL P.
5. As soon as the "#" prompt character appears, enter VIDEO.
6. Wait for the display to show you the VIDEO test menu.
7. Press the 2 key.

** The display now shows you the Touch Sense Test pattern. The purpose of this pattern is to show alignment of the display with respect to the Touch-Sensitive grid. Make sure that the pattern of eights is aligned with the Touch-Sensitive grid. Parallax can cause good alignment to appear bad. Inspect the display from straight on. If the display is not aligned properly, go to the Video Display Alignment Procedure (paragraph 3-50) in the Assembly/Disassembly Procedures.

** If the display is in alignment, go on to part 8 of this step.

8. Press the CTRL C key to return to the menu and go on to the next step.

STEP F. VERIFICATION OF THE ENTIRE PROGRAMMER KEYBOARD

You should be entering this step from Step E, however, you can also use this step as a stand alone verification of the Programmer Keyboard at any time.

1. Load Diagnostic Disk
2. Press RESTART

Table 3-2. Interpreting CVFY Results

TEST	FUNCTION	MODULE	POSITION
1	CPU Instructions	CPU	1
2	Memory	Memory	3
3	Video	Video/Keyboard	6
4	Floppy Disk	See Note #1	2
5	Clock	DMA Floppy/Clock	2
6	IEEE-488	IEEE-488 Interface	7
7	Serial Data Transfer	CPU	1
8	Electronic Disk	Electronic Disk #1	4
9	Electronic Disk	Electronic Disk #2	5
10	Touch Sense	Display	--

Note: #1 A failure of Test 4 (Floppy Disk) can be a result of either a faulty DMA Floppy Module or a faulty Disk Drive unit. If this test fails, go through the Floppy Disk Drive Verification procedure that is a part of the Dead Box Procedure (Step J and K). This allows you to determine which of these two units is at fault.

Note: #2 The optional Electronic Disk modules have a switch that can make any given module #1 or #2. If for some reason you have only one of these modules and it is set up to be #2, the test would show module #1 failing.

3. Wait while the 1720A loads the Diagnostic.

4. As soon as the CVFY Menu appears, press CTRL P.

5. As soon as the "#" prompt character appears, enter VIDEO.

6. Wait for the display to show you the VIDEO test menu.

7. Press the 5 key.

8. Read the Test 5 message.

9. Press RETURN.

10. Press a key on the Programmer Keyboard and wait for the display to fill with the character in reverse video.

** If the display shows any character except the one you selected, then you must replace the programmer keyboard.

11. Continue pressing keys and observing the display until you have verified that all the keys on the Programmer Keyboard are operational.

STEP G. VERIFICATION OF FLOPPY DISK ALIGNMENT

This is a stand alone test of the Floppy Disk Drive. As part of the Live Box Procedure, it verifies the alignment of the Read/Write head in the Disk Drive and acts as a supplement to the CVFY Disk Test. Although this step is a part of the Live Box Procedure, which the Preventative Maintenance Program indicates should be done every 90 days, experience has shown that Disk Drive alignment is rarely a problem. Unless the system is having load problems, or giving some other indication of faulty Disk Drive performance, you may skip this step and still have reasonable assurance that the Disk Drive alignment is correct.

1. Insert the Diagnostic Disk.

2. Press RESTART.

3. Wait while the 1720A loads the Diagnostic.

4. As soon as the CVFY Menu appears, press CTRL P.

5. As soon as the "#" prompt character appears, enter QADISK0.

6. Turn the 1720A up on its side and remove the bottom cover. Locate the Floppy Disk Drive PCB. Use Figure 3-2 (Floppy Disk Drive PCB) throughout the following procedure to locate the various test points on the Disk Drive PCB.

7. Wait for the QADSK0 message. This test is self explanatory. Follow the directions that appear on the display. Refer to the Cat's Eye Alignment Waveform in Figure 3-3, if necessary.

** If the Disk Drive is out of alignment, it must be replaced. You run the risk of creating files that cannot be read on other units that are in alignment or on the current drive if it continues to drift out of alignment. Refer to the appropriate Assembly/Disassembly Procedure and replace the Disk Drive. Restore the system to its normal configuration and repeat this step.

3-15. DEAD BOX PROCEDURE

3-16. Introduction

3-17. As stated in the introduction to this section, the purpose of the Dead Box Procedure is to arrive at a point where the Live Box Procedure can be carried out. Therefore, the Dead Box Procedure assumes that you are faced with either an unusable display and/or a no-load condition. A no-load condition can result from a self-test error or from a hang up of the LOADING process during the start up routine.

3-18. Before using this procedure, read the following notes. Some of them protect the equipment from damage, and others assure that you understand the terminology used in the Dead Box Procedure Steps.

1. Turn power off before removing or inserting any PCB or connector.

2. ** identifies an evaluation and action step or a step that directs you to another part of the procedure.

3. Procedure steps are indicated by the word "Step" followed by a capital letter. Some procedure steps contain several lesser steps. These steps are indented and identified with letters or numbers. When a particular step is referred to, commas separate the designators. For example: Step J, 8, c indicates the c part of the eighth step within Step J.

4. The term "normal configuration" means that the 1720A is set up to run normally. In particular:

   a. All PCBs are in place.

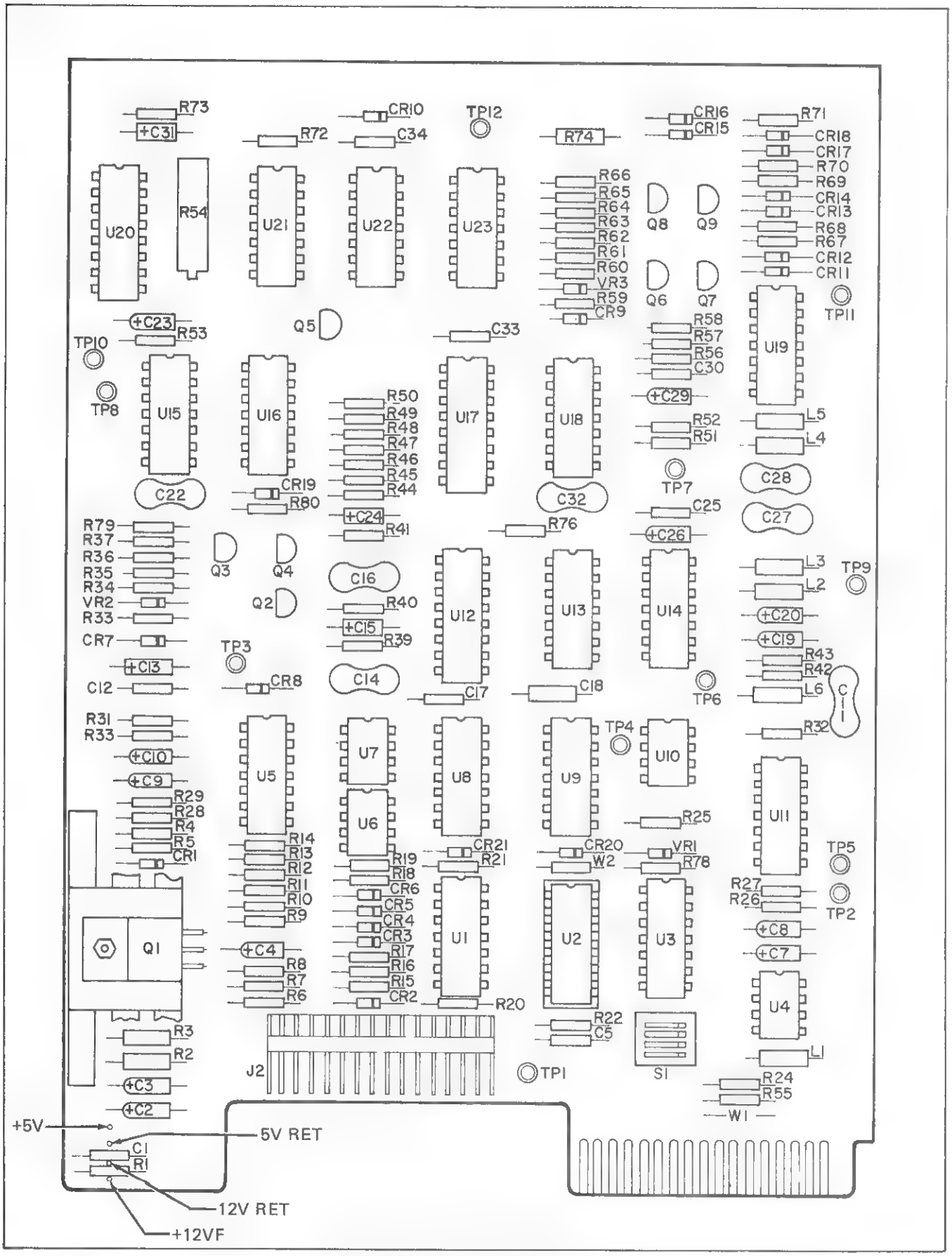


Figure 3-2. Floppy Disk Drive PCB

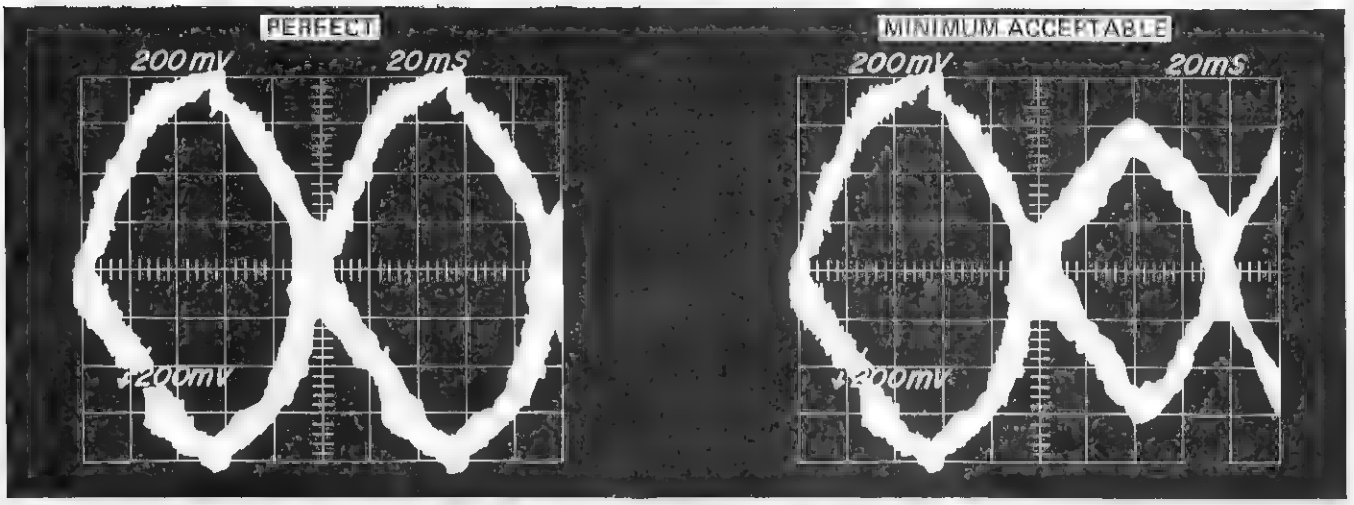


Figure 3-3. Cat's Eye Alignment Waveform

b. Regular PROMs are installed

c. All Normal/Test switches are in Normal.

d. All covers, wires and cables are in place.

e. No test jumpers are in the system.

f. All connectors are installed.

5. Unless otherwise noted, all measurements are made using TP 1 on the Mother Board as a ground reference.

3-19. Dead Box Procedure Steps

STEP A. START

1. Do not insert a disk until the procedure calls for it.

2. Plug the 1720A in and turn the power on.

** If there is no display and the fan is not running (to act as a power on indicator), then you must insure that:

a. Line power is correct.

b. Rear panel power-line fuse is the correct size and not open.

c. The Power Supply has not tripped due to overheating.

d. POWER switch is on.

STEP B. POWER SUPPLY VERIFICATION

The purpose of this step is to determine if the Power Supply is at fault.

1. Turn the power off.

2. Remove the top cover from the instrument.

3. Turn the power on.

4. Refer to Figure 3-4 and verify that all the indicated voltages and the Control Bus signals DCOK and ACOK are present. Check DCOK at TP5 (approximately 3.5V) and check ACOK at P14 pin 32 on the Power Supply Connector (approximately 3.5V).

** If any voltage or signal cannot be verified then go on to Step B.

** If all the voltages can be verified, then go on to Step C.

5. You should be entering this step from Step B, 4; one or more of the Power Supply voltages or signals could not be verified. Part a covers low or missing voltages or signals, and Part b covers out of tolerance voltages that can be adjusted.

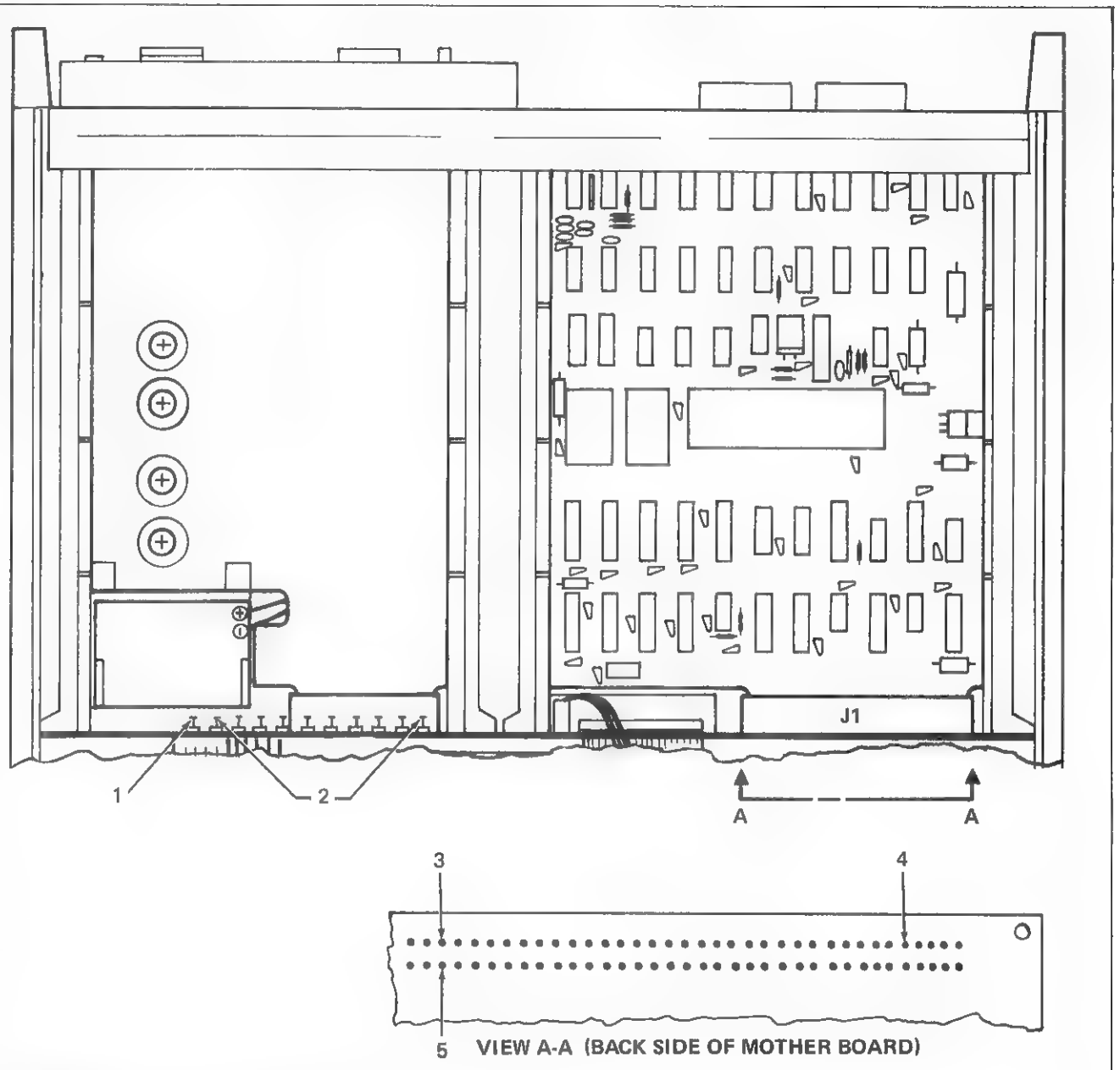
a. Low or missing voltages or signals:

1. Turn power off.

2. Remove the Disk Drive power connector.

3. Remove the CRT Electronics Assembly edge connector.

4. Turn power on.



ITEM NO.	NAME
1	TP11 +70V Return
2	TP1 Common for all voltages except 70V TP2 +5V TP3 +12V TP4 Battery 6.8V TP5 DCOK TP6 −12V TP10 +70.0V with respect to TP11
3	+5VB (pin 5 on J1 Mother Board)
4	−5VB (pin 63 on J1 Mother Board)
5	+12VB (pin 6 on J1 (Mother Board)

NOTE: ALL VOLTAGES ARE ±5% EXCEPT 70V

Figure 3-4. Power Supply Verification

5. Check the Power Supply voltages, DCOK and ACOK as before. The 70V supply should now read approximately 115V with respect to TP11 because the CRT Electronics have been disconnected.

** If the voltages are still incorrect, turn power off, reconnect both connectors and go on to Step B, 5, 7.

** If the voltages are now correct, one of these two assemblies is faulty. Turn power off and re-connect one of the connectors. Turn power on and re-check the Power Supply Voltages, DCOK and ACOK as before. If the voltages are now incorrect, replace the faulty assembly; restore the system to its normal configuration, then run the Live Box Procedure.

6. Repeat this process with the other connector.

7. Turn the E-Disk Battery Switch to the DISABLE position.

8. Remove one of the PCB Modules. Refer to the Assembly/Disassembly Procedures if you do not know how to do this. Notice that if the CPU Module is the one removed, the +12V supply should read approximately 14V and DCOK and ACOK read approximately 1.5V. The other Modules should leave the readings unchanged, if they are removed one at a time, as detailed in the following steps.

9. Recheck the supply voltages.

** If the voltages are now correct then the Module you removed is faulty. Replace it, restore the system to its normal configuration, and run the Live Box Procedure.

** If the voltages are still incorrect, and you have not removed all the Modules one at a time: turn the power off; replace the Module you removed; remove a different module, and turn the power on. Go back and recheck the supply voltages (step 9).

** If the voltages are still incorrect and you have removed all the Modules one at a time, and confirmed that none of them was loading down the Power Supply, then the Power Supply is faulty. Replace it; restore the system to its normal configuration, and run the Live Box Procedure.

b. Out of tolerance voltages that are within adjustment range:

NOTE

All other voltages are slaved to the 5V supply. Adjusting the 5V supply may solve the problem.

1. Monitor TP10 with a DVM. Adjust the 5V adjustment pot until TP10 measures 70.0V.

2. Check that all other supplies are in tolerance.

** If this does not work, the Power Supply may be faulty. Go to part A of this step.

** If this does work, run the Live Box Procedure.

STEP C. SELF TEST AND LOAD

1. Insert the Diagnostic Disk into the Disk Drive.

2. Press RESTART. The system now attempts to run the Self Test program from PROM. On a self test error, it will ask you to "Press any key..." in order to continue.

** If the display remains blank or has a bright background raster, or if no message appears, then go to Step D.

** If there are any Self Test Errors, go to Step D.

3. The system now attempts to run the Load program from the PROM and tries to load the Diagnostic Disk.

** If the word "LOADING" appears, but the load does not finish (no Menu of test options), try a backup Diagnostic Disk (go back to Step C, 1). If you have already tried a new disk, go to Step J.

** If the Menu appears, then remove the Diagnostic Disk and press restart. This forces an error condition (Disk Not Mounted) and the program asks you to 'Press any key to continue'. Press any key on the Programmer Keyboard at this time.

** If the Self Test does not respond (flash the Display) when you press the key, then unplug the Programmer Keyboard and press the Touch-Sensitive Display.

** If the Self Test responds then the Programmer Keyboard must be replaced.

** If the Self Test does not respond, then you have to replace the Video Module. Refer to the appropriate Assembly/Disassembly Procedure; replace the Video Module; restore the system to its normal configuration and run the Live Box Procedure.

** If you tried a backup Diagnostic Disk and the Self Test responded (flashed the Display) when you pressed the key, then you know the Diagnostic Disk

loaded and that your Programmer Keyboard works. Run the Live Box Procedure. If it passes, the original disk you were trying to load is bad.

STEP D. VIDEO VERIFICATION

You should be entering this step from Step C and should have verified that the Power Supply is not at fault. The purpose of this step is to verify that the Video/Keyboard Module (Video Module) is operating correctly so that you can use it in succeeding steps to verify the operation of the other system elements.

1. Turn system power off.

2. Remove the Video Module, referring to the Assembly/Disassembly procedure if necessary, and set the Test/Normal Switch to Test. Reinstall the Video Module.

3. Turn the Power on.

4. Use the Programmer Keyboard and type in a character. Hold the key down until the character completely fills the display. Repeat for all characters.

** If characters are normal then the Video Module is performing correctly. Go on to Step E.

** If characters appear but have a vertical roll, then go to Step M.

** If characters appear but have a horizontal roll, as evidenced by a horizontal drift or a tearing effect, go to Step N.

** If the background raster is visible, covering the entire display area with light, go to Step 0.

** If no characters appear, then turn the Brightness Pot on the rear edge of the Video Module PCB fully CW. If no characters appear, turn the pot back to where it was and go on to Step D.5. If they do appear, adjust the pot for normal viewing and run the Live Box Procedure.

5. If characters do not appear on the display, the fault can be either the Video PCB, the CRT Electronics, or the CRT. Proceed as follows to isolate the fault:

   a. Turn the power off.

   b. Remove the Video Module from the system.

   c. Turn power on.

   d. Attach a jumper between TP5 and TP7 on the Mother Board.

   ** If a full, bright, flickering raster appears, then the Video Module is bad. Replace it; restore the system to its normal configuration, and run the Live Box Procedure.

   ** If the display is other than a full, bright flickering raster, remove the jumper and go to Step L.

STEP E. CPU BOARD VERIFICATION

You should be entering this step from Step D. You have already verified that the Video Module is operating correctly and are now ready to use it in conjunction with the Self Test PROM to verify the operation of the other system elements.

1. Turn power off.

2. Remove the Video Module; set the Normal/Test switch to Normal, and put the module back into the system.

3. Turn power on.

The display should show self test errors for only:
Memory
Floppy
IEEE

** If this condition does not occur, the CPU Module PCB is bad. Replace it and try Step E again.

** If this condition does occur, then go on to the next step.

STEP F. DMA/FLOPPY BOARD VERIFICATION

1. Turn power off.

2. Insert the DMA/Floppy PCB.

3. Turn power on.

The display should show self test errors for only:
Memory
IEEE

** If this condition does not occur, the DMA/Floppy Module PCB is bad. Replace it and try Step G again.

** If this condition does occur, go on to the next step.

STEP G. MEMORY BOARD VERIFICATION

1. Turn power off.

2. Insert the Memory PCB.

3. Turn power on.

The display should show self test errors for only: IEEE

** If this condition does not occur, the Memory PCB is bad. Replace it and try Step G again.

** If this condition does occur, go on to the next step.

STEP H. IEEE-488 BOARD VERIFICATION

1. Turn power off.

2. Insert the IEEE-488 PCB.

3. Turn power on.

The display should show no self test errors.

** If this condition does not occur, the IEEE-488 Module is bad. Replace it and try Step H again.

** If this condition does occur, go on to the next step.

STEP I. OPTIONAL ELECTRONIC DISK BOARD VERIFICATION

1. Turn power off.

2. Insert Electronic Disk PCB #1.

3. Turn power on.

The display should show no self test errors.

** If this condition does not occur, the Electronic Disk PCB is bad. Replace it and try Step I again.

** If this condition does occur, go on to the next step.

4. Repeat with Electronic Disk #2.

STEP J. FLOPPY DISK DRIVE VERIFICATION (READ)

If you are entering this step and can load the Diagnostic Disk (see Note #1 in Table 3-2) then go directly to Step J, 13. If you cannot load a disk, then start at Step J, 1.

1. Turn the power off.

2. Turn the Controller on its side and remove the bottom cover.

3. Turn power on.

4. Refer to Figure 3-2 (Floppy Disk Drive PCB) and verify that all voltages are within specified limits.

** If the voltages are correct, go to the next step (Step J, 5).

** If any of the voltages are outside of the specified limits then the fault is in one of the various connections between the Power Supply and the Floppy Disk Drive unit. Inspect the Floppy Disk Drive unit power connector and the solder connections to the Mother Board.

** Note any broken wires, connector pins, or faulty connections, then call Fluke Service.

5. Install the HALT button in the Power Supply rear connector (P25).

CAUTION

Before going on to the next step, refer to the appropriate Assembly/Disassembly Procedure to install the HDT PROMs.

6. Install the HDT (Hex Debugging Tool) PROMs, and observe the following guidelines as you perform the rest of the procedure:

a. The term "enter" means type the indicated expression on the Programmer Keyboard exactly as shown. An entry is terminated by either a Carriage Return or a Space Bar, as noted. If you make a mistake on any given entry you must press HALT and start over again from the beginning of the series of entries within that step. Be sure that you have the "." prompt character before any entry, especially when starting over. If its not there, press HALT to get it.

b. (SP) indicates the Space Bar.

c. (CR) indicates the Carriage Return key.

d. Lower case N (n) indicates that the display can be any digit or the letters A through F.

e. The ** symbol indicates an evaluation step that steers the operator to other procedural steps.

f. A representation of what the display should look like appears at the end of each step where you have to make these entries. Check your work against this to spot any errors you may have made.

7. Insert an alignment disk and press RESTART. You should get a display as shown below:

```
HDT V1.n.
```

** If this does not work, your HDT PROM set is bad. Try another set.

** If you do get the "." prompt character then go on to the next step.

8. Verify operation of the write protect and disk insertion switches as follows:

a. Set up the scope:

VERT----2 V/cm, DC coupled
HORZ----1 ms/cm
TRIG----Auto (free run)

b. Place the scope probe on U3 pin-12 and observe the level change as a write protected diskette is fully inserted and then withdrawn.

** The level should be >3V (enable) with the diskette fully inserted and should drop to <0.7V (disable) with the diskette out of the unit. If these conditions cannot be met, the Floppy Disk Drive Unit must be replaced. Refer to the appropriate Assembly/Disassembly Procedure and replace the Floppy Disk Drive. Restore the system to its normal configuration, then run the Live Box Procedure.

9. Insert an alignment disk, and press the "B" key on the Programmer Keyboard.

** You should hear a click sound from the Floppy Disk Drive Unit as the head loads. If you do not hear a click, go to Step J, 10. If you do hear a click, then go to Step J, 13.

In addition to the click, the display should show:

```
HDT V1,n

Loading
```

10. Press RESTART

11. Use HDT to load the head by making the following entries:

Enter	HDT Displays
SF3E8(SP) FFFF(CR)	F3E8 nnFF- .
SF3E8(SP) 00FF(CR)	F3E8 .

You should hear a click from the Floppy Disk Drive Unit when you press the last RETURN.

** If you do hear a click, then it means that you have a problem in your CPU Module. Refer to the appropriate Assembly/Disassembly Procedure and replace the CPU Module. Restore the system to its normal configuration then run the Live Box Procedure.

** If you do not hear a click, then go on to the next step.

```
HDT V1.n
 SF3E8
F3E8 nnFF-FFFF
.SF3E8
F3E8 nnFF-00FF
```

Display at end of Step J-11

12. Use HDT to isolate a Drive Unit fault from a Module fault as follows:

a. Leave the scope as in (Step J 8,a). Refer to Figure 3-2. Look at U2 pin-10 on the Floppy Disk Drive Unit PCB.

b. Press RESTART then use HDT to load the head by entering:

Enter	HDT Displays
SF3E8(SP) FFFF(CR)	F3E8 nnFF- .
SF3E8(SP) 00FF(CR)	F3E8 nnFF

** The level on U2 pin-10 should be >3V at the start and should drop to <0.7V at the end. If either of these two conditions are not met, the DMA/Floppy Module is bad. Refer to the appropriate Assembly/Disassembly Procedure; replace the module, and run the Live Box Procedure.

** If both conditions can be met, continue with this step.

HDT V1.n
.SF3E8
F3E8 nnFF-FFFF
.SF3E8
F3E8 nnFF-00FF

Display at end of Step J, 12, b

c. Wait at least 25 seconds (allows a time out to occur).

d. Using the existing scope settings, place the scope probe on U2 pin-6. You should see >3V dc.

e. Press HALT.

f. Make the following entries:

Enter	HDT Displays
SF3E0(SP)	F3E0 nnnn-
300(CR)	.

** The level on U2 pin-6 should be >3V at the start and <0.7V at the end. If either of these two conditions cannot be met, the DMA/Floppy Module is bad. Refer to the appropriate Assembly/Disassembly Procedure and replace the DMA/Floppy Module. Restore the system to its normal configuration, then run the Live Box Procedure.

** If both the conditions can be met, the Floppy Disk Drive Unit is bad. Refer to the appropriate Assembly/Disassembly procedure and replace the Floppy Disk Drive Unit. Restore the system to its normal configuration, and run the Live Box Procedure.

Halt
.SF3E0
.F3E0 nnnn-300
.

Display at end of Step J, 12, f

13. Use HDT to verify the Floppy Disk Drive Radial Track Alignment.

a. Press RESTART.

b. Insert the Alignment Diskette into the Floppy Disk Drive Unit.

c. Refer to Figure 3-2 which shows the Floppy Disk Drive PCB, and use the scope as follows:

1. Attach the scope signal probes to TP2 and TP5. Connect the probe ground leads to TP11.

2. Attach the scope trigger probe to TP4. Connect the probe ground lead to TP1.

3. Set up the scope:

VERT----200 mV/cm, dual trace, A+B, with B inverted
HORZ----20 ms/cm
TRIG----External

d. Enter a program as follows:

Enter	HDT Displays
S100(SP)	0100 nnnn-
2E0(SP)	nnnn-
1000(SP)	nnnn-
4E0(SP)	nnnn-
F3F0(SP)	0108 nnnn-
10FD(CR)	.
SF3E8(SP)	nnnn-
FFFF(CR)	.
SF3E8(SP)	nnnn-
00FF(CR)	.
SF3E0(SP)	nnnn-
300(CR)	.
SF3E6(SP)	nnnn
10FF(CR)	.
SF3E0(SP)	nnnn-
1700(CR)	.
G100(CR)	.G100

** The CPU begins executing the program. This program is a loop that causes the Floppy Drive Unit to do a continuous read of track 16 on the Alignment Diskette. Adjust the scope triggering to obtain the waveform shown in Figure 3-3 (Cat's Eye Alignment Waveform) and complete the evaluation as follows:

1. Measure the amplitude of side A and of side B.

2. Compare A to B. The smaller of the two must be at least 80% of the larger.

3. If this condition is met, the Drive Unit performance of several parameters is verified: Head movement from track 00 to track 16, Read ability, and alignment.

** If this condition is not met, the Floppy Disk Drive Unit is bad. Replace it and run Live Box Procedure.

```
HDT V1.n
.S100
0100 nnnn-2E0 nnnn-1000 nnnn-4E0
nnnn-F3F0
0108 nnnn 10FD
.SF3E8
F3E8 nnnn FFFF
.SF3E8
F3E8 nnnn 00FFF
.SF3E0
F3E0 nnnn 300
.SF3E6
F3E6 nnnn 10FF
.SF3E0
F3E0 nnnn 1700
.G100
```

Display after Step J, 13,d

14. Use HDT to move the head and check for head movement ability.

a. Do not change any of the set up established in Step J, 13.

b. Press HALT

c. Enter the following:

Enter	HDT Displays
SF3E6(SP)	F3E6 nnnn
24FF(CR)	.
SF3E0(SP)	F3E0 nnnn
1700(CR)	.
G100(CR)	

** The Cat's Eye Waveform on the scope should go away as soon as the Carriage Return is complete because head moves off the alignment track (16) and goes to track 32. If the waveform does not go away, the Floppy Disk Drive Unit is bad. Replace it and run the Live Box Procedure.

```
HALT
.SF3E6
F3E6 nnnn 24FF
.SF3E0
F3E0 nnnn 1700
.G100
```

Display at end of Step J, 14, c

d. Press HALT then enter the following:

Enter	HDT Displays
SF3E6(SP)	F3E5 nnnn-
10FF(CR)	.
SF3E0(SP)	F3E0 nnnn
1700(CR)	.
G100(CR)	

** The Cat's Eye waveform should come back again. If it does not come back, it means that the head cannot move from track 32 to track 16. Replace the Floppy Disk Drive Unit and run the Live Box Procedure.

```
HALT
.SF3E6
F3E6 nnnn 10FF
.SF3E0
F3E0 nnnn 1700
G100
```

Display after Step J, 14, d

15. Final read data output verification

a. Allow the Drive Unit to continue reading the alignment track, as in Step J, 14, d.

b. Set up the Scope:

VERT----2 V/cm, single trace, DC coupled
HORZ----1 us cm
TRIG----Internal

c. Refer to Figure 3-2. Place the scope probe on U3 pin 3.

d. Verify that the correct waveform is present at U3 pin-3. The waveform should go from 0V to +5V. The period should be 7.5 us from the leading edge of one positive-going pulse to the leading edge of the next one. The pulse width of the negative-going portion of the waveform should be 1 us. These values are typical and are given for troubleshooting purposes only.

** If the waveform cannot be verified, the Floppy Disk Drive Unit is bad. Replace it, and run the Live Box Procedure.

16. Drive motor speed verification

a. Allow the Drive Unit to continue reading the alignment track, as in Step J, 14, d.

b. Refer to Figure 3-2 which shows the Floppy Disk Drive PCB, and use the scope as follows:

1. Place the probe on U3 pin–6.

2. Set up the scope:

VERT----2 V/cm, single trace, DC coupled
HORZ----50 ms/cm
TRIG----Internal

c. Verify that the waveform is a 4 ms negative-going pulse (5V to 0V) with a repetition rate of 200 ms.

d. Connect a counter-timer to TP4 and measure the duration of the Index to Index pulse. The duration must be 200 ms ± 3 ms.

** If the waveform or timing cannot be verified, the Floppy Drive Unit is bad. Replace it and run the Live Box Procedure.

17. Verification of the track 00 detect switch

a. Press HALT

b. Set up the scope:

VERT----2 V/cm, single trace DC coupled
HORZ----1 ms/cm
TRIG----Auto

Place the probe on U3 pin–8. Since the head is not at track 00, the voltage should be >3V.

** If this condition is not met, replace the Floppy Disk Drive. Refer to the appropriate Assembly/Disassembly Procedure. Restore the system to its normal configuration and run the Live Box Procedure.

c. Enter the following:

Enter	HDT Displays
SF3E0(SP) 300(CR)	F3E0 nnnn-

d. The voltage on U3 pin-8 should drop to <0.7V as soon as the head moves to track 00.

** If this condition is not met, replace the Floppy Disk Drive Unit. Refer to the appropriate Assembly/Disassembly Procedure. Restore the system to its normal configuration and run the Live Box Procedure.

** If all the conditions detailed in Step J are verified, but the system fails CVFY Test 4 (see Table 3-2, Note #1), then go to Step K.

** If all the conditions detailed in Step J are verified, and the system still does not boot (load the Diagnostic Disk), then the DMA Floppy/Clock Module is bad. Replace it, and run the Live Box Procedure.

HALT
.SF3E0
F3E0 nnnn 300

Display at end of Step J, 17, c.

NOTE

Reinstall the regular PROM set. Refer to the appropriate Assembly/Disassembly procedure.

Step K. FLOPPY DISK DRIVE VERIFICATION (WRITE)

The purpose of this step is to diagnose those problems where, the Diagnostic Disk can be loaded but the CVFY test #4 fails, or where some other problem indicates that a Disk Unit can read information from the diskette but cannot write information correctly. It assumes that all the verifications called for in Step J can be made.

1. Load the CVFY program. Refer to the Live Box Procedure for details on CVFY usage.

2. Loop on test 4.

3. Set up the scope for:

Single channel	2V per cm.
Trig.	internal
Horz.	as necessary

4. Verification of the Write Enable signal from the Module.

a. Place the scope probe on U2 pin–11.

b. Verify that the correct waveform is present. This waveform should occur approximately every 4 seconds as the program initiates a write operation. It appears as a burst of rapid non-sychronous activity.

** If this condition is not met, replace the DMA-Floppy Clock Module. Refer to the appropriate Assembly/Disassembly Procedure. Restore the system to its normal configuration and run the Live Box Procedure.

5. Verification of the Write Data from the Module.

a. Move the scope probe from U2 pin-11 and place it on U2 pin-3. Verify that the write data is present.

b. Place the scope probe on U2 pin-3. Verify that the correct waveform is present. This waveform should occur approximately every 4 seconds as the program initiates a write operation. It appears as a burst of rapid non-sychronous activity.

** If this condition is not met, replace the DMA-Floppy Clock Module. Refer to the appropriate Assembly/Disassembly Procedure. Restore the system to its normal configuration and run the Live Box Procedure.

** If you have gone through Step K and found that the Module is sending the correct write signals, then the Floppy Disk Drive Unit is bad. Replace it, and run the Live Box Procedure.

STEP L. VIDEO PROBLEM (Unsynchronized display entry point)

The purpose of this step is to determine which submodule within the CRT Electronics section of the system is bad. You should be entering this step from Step D and should have already determined that the CRT Electronics are not operating properly.

NOTE

A display of a bright dot or line can burn the CRT face. Remove the jumper quickly if anything but a full screen display occurs.

** If you see a blank display, go to Step L, 1

** If you see a horizontal line, go to Step L, 3

** If you don't see any of the above, then call Fluke Service.

1. Blank Display--check filiaments

WARNING

HIGH VOLTAGE IS PRESENT WITHIN THE CRT AREA. DO NOT PLACE HANDS OR METALLIC OBJECTS INTO THIS AREA.

a. Look at the clear glass neck of the CRT, just ahead of the plastic tube socket.

b. Locate the filiament (glowing brightly).

** If you can see the filiament glowing and there is no blue glow from the neck area of the CRT, you can assume that the CRT is good and the CRT Electronics must be replaced. Refer to the appropriate Assembly/Disassembly Procedure. Following this, run the Live Box Procedure.

** If you can see a blue glow in the neck area of the CRT, the CRT is gassy and it must be replaced. Refer to the appropriate Assembly/Disassembly Procedure.

** If you cannot see the filiament glowing, then go on to Step L, 2.

2. Blank Display -- filiament not glowing

a. Turn system power off

WARNING

A POSSIBILITY EXISTS THAT THE HIGH VOLTAGE SUPPLY IS NOT DISCHARGED. FOLLOW THE PROCEDURE OUTLINED IN ASSEMBLY/DISASSEMBLY PROCEDURES (PARAGRAPH 3-37, 9) FOR DISCHARGING THE HIGH VOLTAGE SUPPLY BEFORE GOING ON.

b. After discharging the High Voltage Supply, remove the socket from the base of the CRT.

c. Measure between pins 1 and 8 to check filiament continuity. Five ohms is typical.

** If the filiaments are open, the CRT is bad and must be replaced. Refer to the appropriate Assembly/Disassembly procedures, especially the warning paragraph concerning the dangers involved with the process. Replace the CRT; restore the system to its normal configuration, and run the Live Box Procedure.

d. Measure the resistance in the horizontal yoke coil as follows:

1. Remove the red wire from the horizontal yoke coil.

2. Measure the resistance between the red and black tabs on the yoke coil.

3. The resistance should be 2.2 ohms, nominally. Some variation from this reading is acceptable; however, since there are two windings in parallel, a reading of 4.4 ohms indicates that one winding is open and an open reading indicates both windings are open. Neither of these conditions is acceptable.

** If the reading is not correct, then the yoke is defective. The yoke and CRT are provided as a matched, pre-aligned set for servicing; therefore, the whole CRT Assembly must be replaced. Refer to the appropriate Assembly/Disassembly procedure and replace the CRT Assembly. Carefully note the warning about the danger involved in handling the CRT. Following this, restore the system to its normal configuration.

3. Incorrect Display -- horizontal line
This condition is due to a fault in the vertical drive which can either be the yoke or the CRT electronics.

a. Remove the top cover.

WARNING

High voltage is present within the CRT area. Do not place your hands or metallic objects into this area.

b. Turn system power off.

c. Remove the yellow wire from the yoke. Measure the resistance between the yellow and green tabs on the yoke. There are two windings in series here. Therefore, an open reading is not acceptable. The correct reading is approximately 260 ohms.

** If the reading is not correct, the yoke is defective. The yoke and CRT are provided as a matched, pre-aligned set for servicing, therefore, the CRT must be replaced. Refer to the appropriate Assembly/Disassembly procedures, to replace the CRT assembly, then restore the system to its normal configuration.

** If the reading is correct then the CRT Electronics are faulty. Refer to the appropriate Assembly/Disassembly procedure; replace the CRT Electronics; restore the system to its normal configuration and run the Live Box Procedure.

STEP M. VIDEO ELECTRONICS PROBLEMS (Vertical roll entry point)

You should be entering this step from Step D. You have a display that has characters but displays them with a vertical roll. This problem is caused by a lack of vertical synchronization. The purpose of this step is to determine if the fault is in the Video/Keyboard Module or the CRT Electronics.

1. Remove the top cover from the instrument.

WARNING

High Voltage is present within the CRT area. Do not place your hands or metallic objects into this area.

2. Set up the scope as follows:

VERT single trace, 2V per cm.
SYNC internal, positive
HORZ as necessary

3. Place the scope probe on TP 9 on the Mother Board. You should be able to see positive-going TTL-level (4V approximate) pulses, approximately 190 us wide and 17 ms apart.

** If these pulses are present, then the CRT Electronics must be replaced. Refer to the appropriate Assembly/Disassembly procedure and replace the CRT Electronics. Restore the system to its normal configuration. Run the Live Box Procedure.

** If you do not see these pulses, disconnect the CRT Electronics from the system and look again. Proceed as follows:

1. Turn the power off.

2. Turn the instrument up on its side then remove the bottom cover.

3. Unplug the edge connector from the rear of the bottom CRT Electronics PCB.

4. Turn the power back on. The display is blank with the connector removed.

5. Using the scope, look at TP9 on the Mother Board.

** If the pulses are there, the CRT Electronics must be replaced. Refer to the appropriate Assembly/Dissassembly procedure and replace the CRT Electronics. Restore the system to its

normal configuration, and run the Live Box Procedure.

** If the pulses are not there, replace the Video/Keyboard Module. Refer to the appropriate Assembly/Disassembly procedure. Restore the system to its normal configuration, and run the Live Box Procedure.

STEP N. VIDEO ELECTRONICS PROBLEMS (Horizontal roll entry point)

You should be entering this step from Step D. The display has characters but displays them with a horizontal roll that shows up as a tearing in the horizontal direction. This problem is caused by a lack of horizontal synchronization. The purpose of this step is to find out if the problem is in the Video/Keyboard Module or in the CRT Electronics.

1. Remove the top cover from the instrument.

WARNING

HIGH VOLTAGE IS PRESENT WITHIN THE CRT AREA. DO NOT PUT YOUR HANDS OR METALLIC IMPLEMENTS INTO THIS AREA.

2. Set up the scope as follows:

VERT 2V per cm.
SYNC internal, positive
HORZ as necessary

3. Place the scope probe on TP-8 on the Mother Board. You should be able to see positive-going TTL pulses (approximately 4V) that are approximately 4.5 us wide and 62 us apart.

** If these pulses are present, replace the CRT Electronics. Refer to the appropriate Assembly/Disassembly Procedure. Restore the system its normal configuration, then run the Live Box Procedure.

** If you do not see these pulses, disconnect the CRT Electronics and look again. Proceed as follows:

1. Turn the power off.

2. Turn the instrument up on its side then remove the bottom cover.

3. Unplug the edge connector from the rear of the bottom CRT Electronics PCB.

4. Turn the power back on. The display is blank with the connector removed.

5. Using the scope, look at TP-9 on the Mother Board.

** If the pulses are there, replace the CRT Electronics. Refer to the appropriate Assembly/Disassembly procedure. Restore the system to its normal configuration and run the Live Box Procedure.

** If the pulses are not there, replace the Video/Keyboard Module. Refer to the appropriate Assembly/Disassembly procedure. Restore the system to its normal configuration, and run the Live Box Procedure.

STEP O. VIDEO DISPLAY PROBLEM (Bright display entry point)

You should be entering this step from Step D. The display is bright, covering the entire display area with light (without the jumper between TP5 and TP7 on the Mother Board). The problem can be caused by a fault in the CRT (shorted elements) or in various areas of the CRT Electronics that provide the correct bias for the CRT. The purpose of this step is to find out if the problem is in the CRT itself or in the CRT Electronics.

1. Make a note of the position of the Brightness Pot in the CRT Electronics section. Turn this pot CCW until the background raster just disappears.

** If the background raster will extinguish, return to the beginning of Step D.

** If the background raster will not extinguish, return the pot to its original position and go on to Step O,2.

2. Turn power off.

3. Remove the tube socket from the base of the CRT.

4. Set up the scope (or use a DVM) as follows:

VERT 10V per cm., DC coupled
SYNC Auto
HORZ 1 ms/cm

5. Turn system power back on.

6. Measure the voltage at the center tap of the Brightness Pot in the CRT Electronics. The voltage should be 5V ± 25V (i.e., -20V to +30V). If the

original setting is not certain, verify the adjustment range is at least –20V to +30V.

7. Measure the voltage at the yellow lead to the CRT socket at PCB end of the lead. This voltage should be approximately 70V (but not less than 60V) with no jumper between TP5 and TP7 on the Mother Board. It should drop to approximately 52V with the jumper.

** If the voltages called for in Step O, 6 and 7 are both correct, replace the CRT. If they are not both correct, replace the CRT Electronics. Refer to the appropriate Assembly/Disassembly procedure. Restore the system to its normal configuration, then run the Live Box Procedure.

3-20. ASSEMBLY/DISASSEMBLY PROCEDURES

3-21. Introduction

3-22. The following procedures allow the user to remove and replace any of the modules or assemblies mentioned in either of the diagnostic procedures found at the beginning of this section. The term "module" refers to one of the PCBs within the card cage. The term "assembly" denotes other replaceable portions of the 1720A. Each procedure has its own heading and appears in the table of contents.

3-23. Tools Required

3-24. The only tools required for most of the procedures that follow are:

1. 5-Inch Phillips Screwdriver
2. 5-Inch Slot Screwdriver
3. 24-Pin IC Extractor

3-25. In addition, if you are replacing the CRT Assembly or the Touch Sensitive Display, you need:

1. A 9-inch screwdriver (slot), with a 1/4 inch blade and a plastic handle at least 3 inches long.
2. 1 Kilohm, 1/2 watt, carbon resistor.
3. Two clip leads, with alligator clips, approximately 5 inches long.
4. Safety gloves.
5. Full face shield (preferred) or safety goggles.
6. Long sleeved jacket.
7. Work bench or table, large enough to accomodate the 1720A when laid flat and still leave enough room on either side to allow work on the Front Panel assembly.
8. Soft pad (foam or quilted) approximately 8 by 11 inches.
9. Plastic screwdriver, 9 inches long minimum, 1/4-inch tip approximate. It should be as rigid as possible to resist twisting during the adjustment.
10. Plastic hex-drive alignment tool (for pots in the CRT Electronics area).

3-26. Module (PCB)

3-27. All the PCBs within the 1720A card cage can be removed and replaced using the steps that follow. Refer to Table 3-2 or to the Interconnection Diagram in Section 6, for the slot/location of any module. Both the IEEE-488 Module and the E-Disk Module require one extra step that the others do not.

1. Turn power off and unplug the instrument.
2. Remove the rear card cage cover which is held by three captive retaining screws. Two of the screws are in the rear feet and the third screw is in the middle of the rear section.
3. If you are removing the IEEE-488 Module, remove the screws from the rear edge of the Module. They hold it into the card cage. Skip this step for all other Modules.
4. If you are removing the Electronic Disk Module, turn the E-Disk Battery switch to the DISABLE position. Skip this step for all other modules.
5. Use the PCB ejectors located on the rear edge of the Module to remove the PCB from its socket. To do this, place a thumb under each ejector and pull away from the PCB. As soon as the PCB is out of the socket, slide it all the way out of the card cage.
6. Slide the new PCB into the card cage until it comes to a stop against the socket. Press against the rear edge of the PCB with the palm of your hand to seat the PCB in the socket.
7. Replace the rear card-cage cover.

3-28. Power Supply

3-29. To remove and replace the Power Supply proceed as follows:

1. Turn the power off and unplug the instrument. Wait for at least three minutes before going on to the next step.

2. Back out the three captive retaining screws that hold the Power Supply in. Two of these screws are located in the rear feet and the third screw is located in the center of the rear panel.

3. Slide the Power Supply out of the instrument.

4. Slide the new Power Supply into the unit.

5. Tighten the three captive retaining screws.

6. Refer to the Dead Box Procedure, Step B, and verify that the new supply operates correctly.

3-30. Battery

3-31. To remove and replace the battery, proceed as follows:

1. Turn the power off and unplug the instrument. Wait for at least three minutes before going on to the next step.

2. Back out the three captive retaining screws that hold the Power Supply in. Two of these screws are located in the rear feet and the third screw is located in the center of the rear panel.

3. Slide the Power Supply out of the instrument.

4. Place the Power Supply top down on the bench.

5. Remove the four screws that hold the bottom Power Supply PCB to the main assembly.

6. Gently separate the PCB from the main assembly and lay it to one side at the limit of the wires.

7. Unplug the battery by pulling on the battery plug where it enters the jack at the PCB.

8. Push up on the bottom of the battery to remove it from the battery holder. The battery wires and plug will pass through the bottom of the holder.

9. Install a new battery, routing the wires and plug through the bottom of the holder.

10. Press the battery plug into the jack at the PCB.

11. Replace the PCB on the main assembly.

12. Install the four screws that hold the bottom Power Supply PCB to the main assembly.

13. Slide the Power Supply into the instrument.

14. Tighten the three captive retaining screws that hold the Power Supply in. Two of these screws are located in the rear feet and the third screw is located in the center of the rear panel.

3-32. Floppy Disk Drive

3-33. To remove and replace the Floppy Disk Drive Unit, proceed as follows:

1. Turn power off and unplug the instrument.

2. Remove the top and bottom covers from the instrument.

3. Remove the CPU Module using the Module (PCB) Assembly/Disassembly Procedure.

4. Disconnect the Floppy Drive Unit power cable.

5. Turn the instrument up on one side.

6. Hold the Floppy Disk Drive Unit with one hand while removing the four screws that pass through the bottom mounting plate into the Floppy Disk Drive Unit cover. Be careful not to drop the Floppy Disk Drive when you remove the last screw.

7. Lay the instrument bottom side down, maintaining your hold on the Floppy Disk Drive Unit.

8. Slide the Drive Unit back until it clears the Front Panel. Lift the unit upwards until you can disconnect the ribbon cable. Notice that the red stripe on the edge of the ribbon cable goes towards the center of the 1720A. Since the connector is not keyed, this red stripe provides the only means of correctly reconnecting the cable.

9. Remove the four screws holding the sheet metal cover to the Floppy Disk Drive. Transfer the cover to the new drive and replace the four screws.

10. Connect the ribbon cable to the new Drive, keeping the red stripe towards the center of the instrument. Slide the Drive Unit into the instrument.

11. Hold the Floppy Disk Unit in place and tilt the instrument up on one side. Replace the four screws that pass through the bottom of the Drive Unit Cover. Don't let go of the Drive Unit until you have installed at least one of the screws.

12. Reconnect the power cable.

13. Install the CPU Module.

14. Install the top and bottom covers.

3-34. CRT Assembly

3-35. To remove and replace the CRT Assembly, proceed as follows:

WARNING

BE CAREFUL WHEN YOU HANDLE THE CRT. WEAR PROTECTIVE CLOTHING AND SAFETY GLASSES OR A FULL FACE SHIELD. AVOID STRIKING THE CRT ON ANY OBJECT WHICH MIGHT CAUSE IT TO CRACK OR IMPLODE.

1. Turn the power off and unplug the instrument.

2. Remove the rear card-cage cover which is held by three captive retaining screws. Two of the screws are in the rear feet and the third screw is in the middle of the rear section.

3. Remove the five screws on the rear panel that hold the IEEE-488 Module in place and remove the module.

4. Tilt the 1720A up on its side and remove the top and bottom covers from the instrument.

5. Disconnect the ribbon cable, that connects the Front Panel to the instrument, from the Front Panel. Notice that the red stripe on the edge of the cable goes towards the side of the instrument. Since this connector is not keyed, this red stripe provides the only way to reconnect the cable correctly.

6. Disconnect the multi-color ribbon cable from the Mother Board. Free the cable from the clamp on the Floppy Drive mounting plate. Note that the brown wire on the edge of the cable goes toward the center of the instrument. Since this connector is not keyed, the position of this brown wire provides the only means to reconnect the cable correctly.

7. Remove the two screws that pass through the Floppy Disk Drive Unit support bracket into the Front Panel bezel.

8. Turn the box bottom side down. Do not crush the loose ribbon cables or connectors against the bench.

WARNING

BOTH THE CRT ANODE AND THE HIGH VOLTAGE SUPPLY MAY RETAIN A HIGH VOLTAGE CHARGE AFTER THE INSTRUMENT HAS BEEN TURNED OFF FOR SOME TIME. IN THE CASE OF THE CRT ANODE THIS CHARGE CAN BUILD BACK UP EVEN AFTER BEING DISCHARGED BY THE PROCEDURE THAT FOLLOWS. ALTHOUGH NOT CONTAINING ENOUGH ENERGY TO BE HARMFUL, THE CHARGE CAN DELIVER A SHOCK THAT COULD CAUSE THE CRT TO BE DROPPED.

9. Discharge the high voltage charge through a 1 Kilohm resistor as follows:

a. Connect one end of the resistor to the chassis with one clip lead.

b. Connect the other end of the resistor to the shaft of the 9 inch screwdriver with the 1/4 inch tip, using the other clip lead.

c. Hold the screwdriver by its plastic handle and gently slip it under the edge of the plastic nipple on the CRT end of the high voltage lead; keep the blade flat against the glass envelope. Slide the blade forward until the screwdriver blade touches the metallic clip at the end of the high voltage lead. You must be careful not to scratch the surface of the CRT.

10. Remove the High Voltage lead from the side of the CRT as follows:

a. Grasp the rubber insulating nipple firmly and slide it sideways against the tension of the wire prongs that are inside the nipple. This should unlock the connector.

b. Pull the nipple outwards while maintaining the sideways pressure to remove the connector.

c. Notice how the High Voltage cable is dressed. It is important to copy this dressing when reconnecting the High Voltage lead because it minimizes corona losses by staying as far from all grounded surfaces as possible.

11. Remove the rear connector from the base end of the CRT neck.

12. Remove the 4 wires from the yoke. Note that they are on color coded tabs.

13. Remove the side decals from the handles. New decals are provided in the kit for the CRT Assembly.

14. Remove the four screws that hold each handle to the side of the instrument.

15. Ease the Front Panel forward, away from the instrument, until it is just free from the sides.

16. Gently pull the Front Panel toward you until the neck of the CRT is free of the instrument. Notice how the Front Panel ribbon cable is dressed, particularly where it passes the CRT support bracket. To avoid damage to the cable, duplicate this dressing when you reassemble the instrument.

17. Set the Front Panel face down on a clear area of the bench with the neck of the CRT pointing up.

18. Don protective clothing:

a. Full face shield (preferred) or protective goggles.

b. Long sleeved jacket.

c. Protective gloves.

19. Remove the four screws from the CRT support brackets.

20. Remove the support brackets.

21. Grasp the CRT on each side of the bulb. Lift it straight up being careful to leave the face pointing down. Do not strike it against anything.

22. Gently set the CRT face-down on a soft pad in a clear protected area of the bench. The purpose of this pad is to prevent scratching the face of the CRT and to avoid placing the CRT on a hard surface. If theTouch-Sensitive Display is stuck to the CRT, remove it and place it back into the Front Panel, but keep the CRT face down at all times.

23. Unpack the new CRT Assembly, using your protective clothing and being careful not to strike the CRT against anything that may crack the glass envelope.

a. Remove the protective cover from the base of the CRT.

b. Hold the CRT by the bulb, curling your fingers around the edges onto the face.

c. Place it face down, into the Front Panel with the socket for the High Voltage Lead towards the center of the panel.

24. Install the CRT support brackets and the four screws that secure the CRT to the Front Panel. You may remove your protective clothing at this time.

25. Observe that each side of the front panel has guides that are meant to accomodate notches that are in the sheet metal sides of the instrument. Carefully rotate the Front Panel away from you to place it in the correct relative position that allows you to reinstall it in the instrument. The guides on each side of the Front Panel should now be directly in line with the notches in the sheet metal sides.

26. Route the Front Panel ribbon cable in such a way that it will not be sheared off by the sheet metal portion of the box on the underside of the instrument when you replace the Front Panel.

27. Move the Front Panel toward the instrument, being careful that the sheet metal notches correctly enter the guides on each side of the Front Panel. Continue this movement until the Front Panel is all the way onto the instrument and the guides are all the way into the notches. The holes in the handles should match up with the corresponding holes in the Front Panel. Insure that the ground spring is making proper contact with the outside of the CRT.

28. Install the four screws on each handle that hold it to the side of the instrument.

29. Replace the side decals on the handles. New decals are provided in the kit for the CRT Assembly.

30. Connect the 4 wires to the yoke. Note that they are on color coded tabs.

31. Attach the rear connector to the socket end of the CRT neck.

32. Connect the High Voltage lead on the side of the CRT as follows:

a. Grasp the rubber insulating nipple firmly and press the anode connector into the socket on the side of the CRT.

b. It is important to copy the original dressing when reconnecting the High Voltage lead because it minimizes corona losses by staying as far from all grounded surfaces as possible.

33. Turn the box top side up. Do not crush the loose ribbon cables or connectors against the bench.

34. Install the two screws that pass through the Floppy Disk Drive Unit support bracket into the Front Panel bezel.

35. Connect the multi-color ribbon cable from the Mother Board. Insert the cable into the clamp on the Floppy Drive mounting plate. Note that the brown wire on the edge of the cable goes toward the center of the instrument. Since this connector is not keyed, the position of this brown wire provides the only means to reconnect the cable correctly.

36. Connect the ribbon cable to the Front Panel. Notice that the red stripe on the edge of the cable goes toward the side of the instrument. Since this connector is not keyed, this red stripe provides the only way to reconnect the cable correctly.

37. Tilt the 1720A up on its side and replace the top and bottom covers on the instrument.

38. Install the IEEE Module, insuring that it is firmly seated. Install five screws that hold the IEEE Module in place.

39. Install the rear card cage cover which is held by three captive retaining screws. Two of the screws are in the rear feet and the third screw is in the middle of the rear section.

40. Plug the instrument in and go through the Video Alignment Procedure given in paragraph 3-50.

3-36. Touch-Sensitive Display

3-37. To replace the Touch-Sensitive Display, proceed as follows:

WARNING

BE CAREFUL WHEN YOU HANDLE THE CRT. WEAR PROTECTIVE CLOTHING AND SAFETY GLASSES OR A FULL FACE SHIELD. AVOID STRIKING THE CRT ON ANY OBJECT WHICH MIGHT CAUSE IT TO CRACK OR IMPLODE.

1. Turn the power off and unplug the instrument.

2. Remove the rear card-cage cover which is held by three captive retaining screws. Two of the screws are in the rear feet and the third screw is in the middle of the rear section.

3. Remove the five screws on the rear panel that hold the IEEE-488 Module in place and remove the module.

4. Tilt the 1720A up on its side, and remove the top and bottom covers from the instrument.

5. Disconnect the ribbon cable, that connects the Front Panel to the instrument, from the Front Panel. Notice that the red stripe on the edge of the cable goes towards the side of the instrument. Since this connector is not keyed, this red stripe provides the only way to reconnect the cable correctly.

6. Disconnect the multi-color ribbon cable from the Mother Board. Free the cable from the clamp on the Floppy Drive mounting plate. Note that the brown wire on the edge of the cable goes toward the center of the instrument. Since this connector is not keyed, the position of this brown wire provides the only means to reconnect the cable correctly.

7. Remove the two screws that pass through the Floppy Disk Drive Unit support bracket into the Front Panel bezel.

8. Turn the box bottom side down. Do not crush the loose ribbon cables or connectors against the bench.

WARNING

BOTH THE CRT ANODE AND THE HIGH VOLTAGE SUPPLY MAY RETAIN A HIGH VOLTAGE CHARGE AFTER THE INSTRUMENT HAS BEEN TURNED OFF. DO NOT SKIP THE FOLLOWING STEP WHICH SAFELY REMOVES THIS CHARGE.

9. Discharge the high voltage charge through a 1 kilohm resistor as follows:

a. Connect one end of the resistor to the chassis with one clip lead.

b. Using the other clip lead, connect the other end of the resistor to the shaft of the 9-inch screwdriver with the 1/4-tip.

c. Hold the screwdriver by its plastic handle and gently slip it under the edge of the plastic nipple on the CRT end of the high voltage lead. Keep the blade flat against the glass envelope. Slide the screwdriver blade forward until it touches the metallic clip at the end of the high voltage lead. Be careful not to scratch the surface of the CRT.

10. Remove the High Voltage lead from the side of the CRT as follows:

a. Grasp the rubber insulating nipple firmly and slide it sideways against the tension of the wire prongs that are inside the nipple. This should unlock the connector.

b. Pull the nipple outwards while maintaining the sideways pressure to remove the connector.

c. Notice how the High Voltage cable is dressed. It is important to copy this dressing when reconnecting the High Voltage lead because this minimizes corona losses by staying as far from all grounded surfaces as possible.

11. Remove the rear connector from the base of the CRT neck.

12. Remove the 4 wires from the yoke. Note that they are on color coded tabs.

13. Remove the side decals from the handles. New decals are provided in the kit for the CRT Assembly.

14. Remove the four screws that hold each handle to the side of the instrument.

15. Ease the Front Panel forward, away from the instrument, until it is just free from the sides.

16. Gently pull the Front Panel towards you until the neck of the CRT is free of the instrument. Notice how the Front Panel ribbon cable is dressed, particularly where it passes the CRT support bracket. To avoid damage to the cable, duplicate this dressing when you reassemble the instrument.

17. Set the Front Panel face down on a clear area of the bench with the neck of the CRT pointing upwards.

18. Don protective clothing:

a. Full face shield (preferred) or protective goggles.

b. Long sleeved jacket.

c. Protective gloves.

19. Remove the four screws from the CRT support brackets.

20. Remove the support brackets.

21. Grasp the CRT on each side of the bulb. Lift it straight up being careful to leave the face pointing down. Do not strike it against anything.

22. Gently set the CRT face-down on a soft pad in a clear, protected area of the bench. If the Touch-Sensitive Display is stuck to the CRT, remove it and place it to one side. Note the routing of the Display cable. Keep the CRT face down at all times.

23. Lift out the old Touch-Sensitive Display (if it is still in the Front Panel), taking care to note the routing of the ribbon cable. Put the new Touch-Sensitive Display in, using the same cable routing.

24. Install the CRT Assembly, using your protective clothing. Be careful not to strike the CRT against anything that may crack the glass envelope.

a. Hold the CRT by the bulb, curling your fingers around the edges onto the face.

b. Place it face down, into the Front Panel with the socket for the High Voltage Lead towards the center of the panel.

25. Install the CRT Support brackets and the four screws that secure the CRT to the Front Panel. You may remove your protective clothing at this time.

26. Observe that each side of the front panel has guides that are meant to accomodate notches that are in the sheet metal sides of the instrument. Carefully rotate the Front Panel away from you to place it in the correct relative position that will allow you to reinstall it in the instrument. The guides on each side of the Front Panel should now be directly in line with the notches in the sheet metal sides.

27. Route the Front Panel ribbon cable in such a way that it will not be sheared off by the sheet metal portion of the box on the underside of the instrument when you replace the Front Panel.

28. Move the Front Panel towards the instrument, being careful that the sheet metal notches correctly enter the guides on each side of the Front Panel. Continue this movement until the Front Panel is all the way onto the instrument and the guides are all the way into the notches. The holes in the handles should match up with the corresponding holes in the Front Panel. Insure that the ground spring is making proper contact with the ouside of the CRT.

29. Install the four screws from each handle that hold it to the side of the instrument.

30. Replace the side decals from the handles. New decals are provided in the kit for the CRT Assembly.

31. Connect the 4 wires to the yoke. Note that they are on color coded tabs.

32. Connect the rear connector to the base of the CRT neck.

33. Connect the High Voltage lead to the side of the CRT as follows:

a. Grasp the rubber insulating nipple firmly and press the anode connector into the socket on the side of the CRT.

b. It is important to copy the original dressing when reconnecting the High Voltage lead because it minimizes corona losses by staying as far from all grounded surfaces as possible.

34. Turn the box bottom side down. Do not crush the loose ribbon cables or connectors against the bench.

35. Install the two screws that pass through the Floppy Disk Drive Unit support bracket into the Front Panel bezel.

36. Connect the multi-color ribbon cable from the Mother Board. Insert the cable into the clamp on the Floppy Drive mounting plate. Note that the brown wire on the edge of the cable goes towards the center of the instrument. Since this connector is not keyed, the position of this brown wire provides the only means to reconnect the cable correctly.

37. Connect the ribbon cable at the Front Panel. Notice that the red stripe on the edge of the cable goes towards the side of the instrument. Since this connector is not keyed, this red stripe provides the only way to reconnect the cable correctly.

38. Tilt the 1720A up on its side, and install the top and bottom covers from the instrument.

39. Install the IEEE Module, insuring that it is firmly seated. Install the five screws that hold the IEEE Module in place.

40. Install the rear card-cage cover which is held by three captive retaining screws. Two of the screws are in the rear feet, and the third screw is in the middle of the rear section.

3-38. CRT Electronics Assembly/Disassembly Procedure

3-39. REPLACEMENT OF THE HIGH VOLTAGE MODULE

1. Turn the power off, and unplug the instrument.

2. Remove the top and bottom covers from the instrument.

WARNING

BOTH THE CRT ANODE AND THE HIGH VOLTAGE SUPPLY MAY RETAIN A HIGH VOLTAGE CHARGE AFTER THE INSTRUMENT HAS BEEN TURNED OFF FOR SOME TIME. DO NOT SKIP THE FOLLOWING STEP WHICH SAFELY REMOVES THIS CHARGE.

3. Discharge the high voltage charge through a 1 Kilohm resistor as follows:

a. Connect one end of the resistor to the chassis with one clip lead.

b. Connect the other end of the resistor to the shaft of the 9-inch screwdriver with the 1/4-inch tip using the other clip lead.

c. Hold the screwdriver by its plastic handle and gently slip it under the edge of the plastic nipple on the CRT end of the high voltage lead. Keep the blade flat against the glass envelope. Slide the screwdriver blade forward until it touches the metallic clip at the end of the high voltagelead. You must be careful not to scratch the surface of the CRT.

4. Remove the High Voltage lead from the side of the CRT as follows:

a. Grasp the rubber insulating nipple firmly and slide it sideways against the tension of the wire prongs that are inside the nipple. This should unlock the connector.

b. Pull the nipple outwards while maintaining the sideways pressure to remove the connector.

c. Notice how the High Voltage cable is dressed. It is important to copy this dressing when reconnecting the High Voltage lead because it minimizes corona losses by staying as far from all grounded surfaces as possible.

5. Remove the three flyback wires from the CRT Electronics PCB at the side of the unit. Notice that the wire color codes are labeled on the PCB.

6. Remove the two wires from the High Voltage Module. The orientation of these two wires is not critical.

7. Remove the ground wire by removing the screw that passes through the tab into the High Voltage Module.

8. Tilt the instrument up on one side, bottom towards you.

9. Remove the four screws from the bottom that hold the High Voltage Module in place. To prevent the High Voltage Module from falling onto the CRT, support the module with one hand as you remove the last screw.

10. Remove the High Voltage Module.

11. Remove the sheet metal cover from the High Voltage Module. Observe the lead dress of the HV transformer lead to the diode. This dress must be duplicated upon reassembly to minimize corona.

12. Pull the diode out of the white insulator connector, leaving it in the lead to the HV transformer.

13. Remove the three screws that hold the high voltage transformer in place.

14. Remove the High Voltage Transformer.

15. Replace the High Voltage Transformer and the diode that comes with it. Install the three screws that hold it in place.

16. Push the new diode into the white insulator connector.

NOTE

The lead dress of the HV wire to the diode inside the High Voltage Module is critical. Dress it in an "s" loop over the transformer winding and away from the cover and core.

17. Install the sheet metal cover.

18. Install the two screws that hold the insulator in the sheet metal cover.

19. Place the High Voltage Assembly in position and hold it there as you tilt the instrument up on its side (with the bottom of the instrument toward you).

20. Install the four screws that hold the assembly in place. Support the assembly until you have installed at least one of the screws.

21. Attach the ground wire to the screw that passed through the tab into the High Voltage Module.

22. Replace the two wires to the High Voltage Module. The orientation of these two wires is not critical.

23. Replace the three flyback wires to the CRT Electronics PCB at the side of the unit. Notice that the wire color codes are labeled on the PCB.

24. Connect the high voltage lead by pressing the two prongs inside the nipple into the socket on the side of the CRT Assembly. Be sure to duplicate the dressing of the original lead. This minimizes corona losses by keeping the leads as far from all grounded surfaces as possible.

3-40. REPLACEMENT OF THE CRT ELECTRONICS PCB

1. Unplug the four yoke wires.

2. Remove the three flyback wires from the CRT Electronics PCB at the side of the unit. Notice that the wire color codes are labeled on the PCB.

3. Remove the socket from the base of the CRT.

4. Remove the Raster Pot from the chassis bracket.

5. Remove the four screws from the side of the instrument that hold the CRT Electronics Assembly.

6. Tilt the instrument up onto the side opposite to the CRT. This allows the CRT Electronics Assembly to rest on the bench.

7. Position the new assembly on the bench in place of the old.

8. Lay the instrument back down over the assembly.

9. Install the four screws (in the side of the instrument) that hold the CRT Electronics Assembly.

10. Install the new Raster Pot.

11. Connect the socket on the base of the CRT.

12. Connect the three flyback wires on the CRT Electronics PCB at the side of the unit. Notice that the wire color codes are labeled on the PCB.

13. Connect the four yoke wires, matching colors on the wires to the colors on the tabs.

14. Install the top and bottom covers.

15. Plug the instrument in and go through the Video Monitor Alignment Procedure.

3-41. Battery Fuse

3-42. To remove and replace the battery fuse, proceed as follows:

1. Turn the power off, and unplug the instrument. Wait for at least three minutes before going on to the next step.

2. Back out the three captive retaining screws that hold the Power Supply in. Two of these screws are located in the rear feet and the third screw is located in the center of the rear panel.

3. Slide the Power Supply out of the instrument.

4. Place the Power Supply top down on the bench.

5. Remove the four screws that hold the bottom Power Supply PCB to the main assembly.

6. Gently separate the PCB from the main assembly and lay it to one side at the limit of the wires.

7. Locate F1 on the PCB and remove it.

8. Replace F1 with a 5A Slo-blo fuse.

9. Position the Power Supply PCB on the main assembly.

10. Replace the four screws that hold the bottom Power Supply PCB to the main assembly.

11. Slide the Power Supply into the instrument.

12. Tighten the three captive retaining screws that hold the Power Supply In. Two of these screws are located in the rear feet and the third screw is located in the center of the rear panel.

3-43. HDT and Standard Prom Sets

3-44. HDT PROM Set

3-45. To remove the standard PROM Set and install the HDT PROM Set proceed as follows:

CAUTION

Static discharge can damage MOS components. Observe the cautions outlined at the beginning of this section in the STATIC AWARENESS notice while removing or replacing PROMs.

1. Turn the power off.

2. Locate the two PROMs.

3. Use a 24-Pin IC extractor to remove the PROMs. Store the removed PROMs in an appropriate anti-static container.

4. Notice that each of the HDT PROMs has a different part number. Locate the correct socket for each PROM.

5. Insert the HDT PROMs into the sockets with care, making sure that:

   a. The PROMs are orientated correctly with the locating key on the IC package in the same position as shown.

   b. No IC pin is bent or outside its hole.

3-46. Standard PROM Set

3-47. To remove the HDT PROM Set and install the Standard PROM Set, proceed as follows:

CAUTION

Static discharge can damage MOS components. Observe the precautions outlined at the beginning of this section in the STATIC AWARENESS notice while removing or replacing PROMs.

1. Turn the power off and unplug the instrument.

2. Locate the two PROMs.

3. Use a 24-Pin IC extractor to remove the PROMs. Store the removed PROMs in an appropriate anti-static container.

4. Notice that each of the standard PROMs has a different part number. Locate the correct socket for each PROM.

5. Insert the standard PROMs into the sockets with care, making sure that:

a. The PROMs are orientated correctly with the locating key on the IC package in the same position as shown.

b. No IC pin is bent or outside its hole.

3-48. Programmer Keyboard PCB

3-49. To remove and replace the Programmer Keyboard PCB proceed as follows:

1. Unplug the Programmer Keyboard from the instrument and lay it upside down on the bench.

2. Remove the four screws (from the bottom of the unit) that hold the two halves of the case together.

3. Lift the bottom off to the extent of the cable.

4. Pull the PCB up and out, unplugging the cable from the edge connector on the PCB.

5. Plug the new PCB in, using the cable you just unplugged from the old one.

6. Install the new PCB in the top half of the case (which is face down on the bench), insuring that the two alignment pegs on the case go into the holes in the PCB.

7. Push the cable into the U shaped channel next to the connector and press it into the groove in the side of the support post that sticks up to meet the bottom plate of the case.

8. Install the bottom plate. The cable should exit as before.

9. Install the four screws that hold the two halves of the case together.

3-50. Video Display Alignment Procedure

3-51. This procedure can be used after replacement of either the CRT Electronics or the CRT Assembly or used as reference material at any time the display needs adjustment.

NOTE

Display alignment is affected by temperature, supply voltage, brightness, and external magnetic fields. These effects should be considered before any adjustments are made.

3-52. To align the display, proceed as follows:

1. Turn the power on and allow the instrument to warm up to normal operating temperature.

NOTE

Changes in temperature will typically affect vertical size and position by one-half of a character and affect horizontal size and position by two characters.

2. The 70V supply must be 70V ± 0.5V. Use the 5V adjustment to bring it into tolerance if necessary, but make sure that this adjustment does not force the other supplies out of tolerance. Refer to the Power Supply Verification topic in the Dead Box Procedure if you have problems.

3. Establish the CRT alignment display by running the VIDEO program:

a. Press CTRL P on the Programmer Keyboard to get into the CONSOL MONITOR and get the # prompt character.

b. Enter VIDEO (CR).

c. Wait for the Menu to appear.

d. Type the number 1. Do not press RETURN.

e. To check the alignment, use the transparent CRT Alignment Guage supplied in the Customer Maintenance Kit or purchased separately. Figure 3-5 shows this guage as it would appear when placed over the pattern. At normal operating temperatures (25 C ± 5 C), the vertical size and position should be within one-half of a character and the horizontal size and position should be within one character at the reference marks on the guage.

4. Touch-up the intensity by using the Brightness Pot on the rear of the Video Module PCB. The final brightness level should suit the ambient lighting level of the area the instrument will be used in without causing the characters to bloom.

5. Adjust the Raster Pot in the CRT Electronics area.

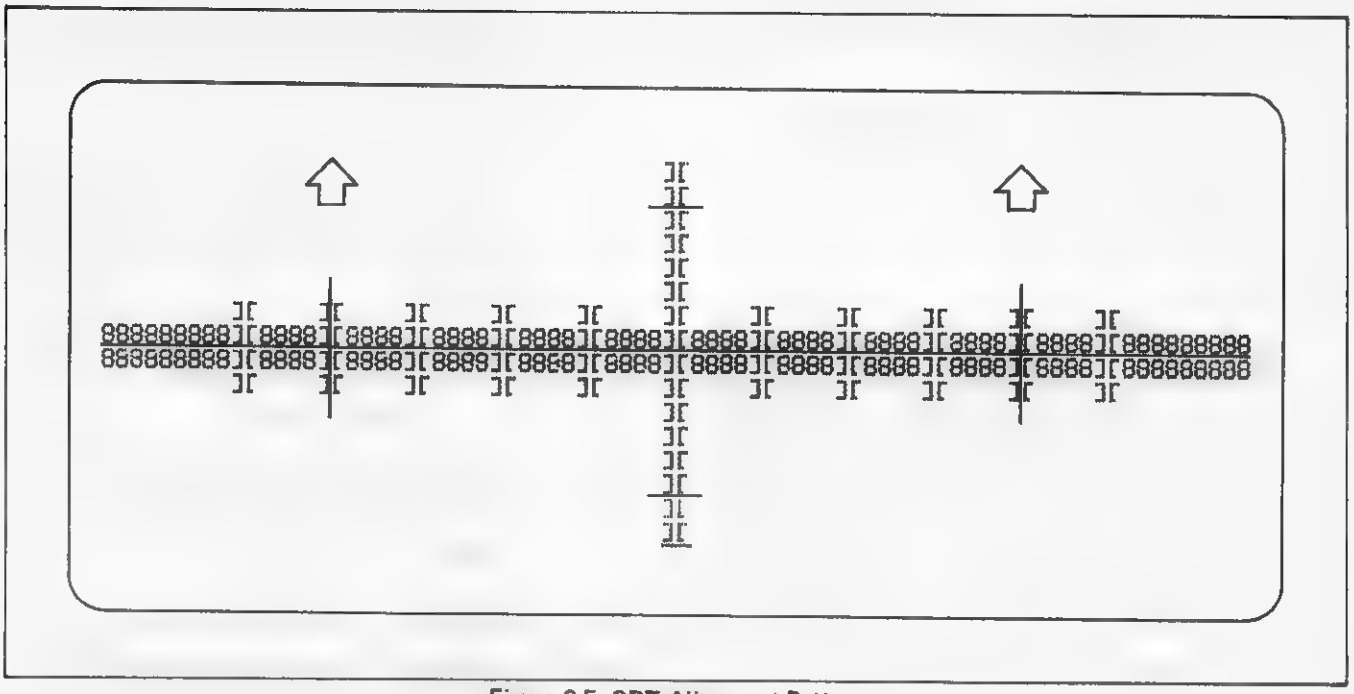


Figure 3-5. CRT Alignment Pattern

NOTE

This pot is factory adjusted to set maximum brightness and should not be adjusted unless the background raster becomes visible during normal usage or new assemblies (CRT Assembly or CRT Electronics) have been installed.

a. Turn the Raster Pot CW until the background raster becomes visible. If you adjust the pot all the way CW and the background raster does not appear, the Master Brightness Pot in the CRT Electronics area must be adjusted. Use a plastic screwdriver on this pot to avoid accidently shorting out adjacent components. Adjust as follows:

1. Turn the Raster Pot in the CRT Electronics area back approximately 1/4 turn.

2. Advance the Master Brightness Pot CW until the background raster just appears.

3. Turn the Raster Pot in the CRT Electronics area CCW until the background raster just disappears. If this cannot be done, the Master Brightness Pot is set too far CW.

b. Back off the adjustment (CCW) until the raster just disappears.

6. Do this step only if new CRT Electronics have been installed. Verify that the video display is centered in the raster as follows:

a. Turn the Raster Pot CW until the raster is visible.

b. Adjust the Horizontal Size coil L53 and the yoke centering rings as necessary so that both right and left sides of the raster can be seen.

NOTE

The centering rings should be adjusted only if really necessary. Notice the present position of the rings and put little tabs of masking tape on the yoke to mark the position they are in.

1. When you move the centering rings together, the raster moves in a circle. If you move the rings individually, the circle of movement changes diameter. Try to center the raster by moving the rings together. Move them individually only if the range of adjustment is not correct.

2. If all movements make things worse, return the rings to their original position and start over.

c. Adjust the Horizontal Osc Coil L50 to center the video display in the center of the raster.

d. If the display is not centered vertically, replace the Video Board.

e. Reduce the raster to the cut off point.

7. Adjust the yoke tilt as follows:

a. Roughly center the display using the centering rings.

1. When you move these rings together, the display moves in a circle. If you move the rings individually, the circle of movement changes diameter. Try to center the display by moving the rings together. Move them individually only if the range of adjustment is not correct.

2. If all movements make things worse, return the rings to their original position and start over.

b. Roughly set the horizontal size and vertical linearity using the Horizontal Size and Vertical Linearity pots.

c. Loosen the yoke clamp screw.

d. Position the alignment guage on the display. Rotate the yoke until the center rows of characters displayed are aligned with the center line of the guage.

e. Insure that the yoke is positioned tightly against the curved funnel of the CRT and tighten the yoke clamp screw to 6-inch pounds.

f. Verify that the tilt is still in adjustment and readjust as necessary.

8. Display Alignment

a. Adjust the horizontal size and centering for alignment to the two vertical marks under the arrows on the guage to within one-half of a character. Use the Horizontal Size Pot and the Centering rings.

b. Adjust the vertical size, centering and linearity so that the center column of characters is aligned with the horizontal marks within one-half of a character. Use the Vertical Size Pot, the Vertical Linearity Pot, and the Centering Rings as necessary.

9. Focus

CAUTION

Use an insulated screw driver.

a. Locate the Focus Pot R70.

b. Adjust for overall focus.

3-53. PREVENTATIVE MAINTENANCE PROGRAM

3-54. The Preventative Maintenance Program for the 1720A consists of three parts.

Part 1

Run the Live Box Procedure every 90 days. This insures that the system is operating correctly.

Part 2

Clean the Air Filter on the rear of the instrument every 90 days or as site conditions dictate. Instructions for cleaning the Air Filter are printed on the rear of the instrument.

Part 3

Clean the Touch-Sensitive Display every 90 days or as site conditions dictate. Use a moist, soft (non-abrasive) cloth and a mild soap solution to clean the Display.

Section 4
General Information

4-1. This section of the manual contains:

List of Abbreviations

Federal Supply Codes for Manufactures

Fluke Technical Service Centers - U.S. and Canada

Fluke Technical Service Centers - International

Sales Representatives - U.S. and Canada

Sales Representatives - International

List of Abbreviations and Symbols

A or amp	ampere	**hf**	high frequency	**(+) or pos**	positive
ac	alternating current	**Hz**	hertz	**pot**	potentiometer
af	audio frequency	**IC**	integrated circuit	**p-p**	peak-to-peak
a/d	analog-to-digital	**if**	intermediate frequency	**ppm**	parts per million
assy	assembly	**in**	inch(es)	**PROM**	programmable read-only memory
AWG	american wire gauge	**intl**	internal		
B	bel	**I/O**	input/output	**psi**	pound-force per square inch
bcd	binary coded decimal	**k**	kilo (10^3)	**RAM**	random-access memory
°C	Celsius	**kHz**	kilohertz	**rf**	radio frequency
cap	capacitor	**kΩ**	kilohm(s)	**rms**	root mean square
ccw	counterclockwise	**kV**	kilovolt(s)	**ROM**	read-only memory
cer	ceramic	**lf**	low frequency	**s or sec**	second (time)
cermet	ceramic to metal(seal)	**LED**	light-emitting diode	**scope**	oscilloscope
ckt	circuit	**LSB**	least significant bit	**SH**	shield
cm	centimeter	**LSD**	least significant digit	**Si**	silicon
cmrr	common mode rejection ratio	**M**	mega (10^6)	**serno**	serial number
comp	composition	**m**	milli (10^{-3})	**sr**	shift register
cont	continue	**mA**	milliampere(s)	**Ta**	tantalum
crt	cathode-ray tube	**max**	maximum	**tb**	terminal board
cw	clockwise	**mf**	metal film	**tc**	temperature coefficient or temperature compensating
d/a	digital-to-analog	**MHz**	megahertz		
dac	digital-to-analog converter	**min**	minimum	**tcxo**	temperature compensated crystal oscillator
dB	decibel	**mm**	millimeter		
dc	direct current	**ms**	millisecond	**tp**	test point
dmm	digital multimeter	**MSB**	most significant bit	**u or μ**	micro (10^{-6})
dvm	digital voltmeter	**MSD**	most significant digit	**uhf**	ultra high frequency
elect	electrolytic	**MTBF**	mean time between failures	**us or μs**	microsecond(s) (10^{-6})
ext	external	**MTTR**	mean time to repair	**uut**	unit under test
F	farad	**mV**	millivolt(s)	**V**	volt
°F	Fahrenheit	**mv**	multivibrator	**v**	voltage
FET	Field-effect transistor	**MΩ**	megohm(s)	**var**	variable
ff	flip-flop	**n**	nano (10^{-9})	**vco**	voltage controlled oscillator
freq	frequency	**na**	not applicable	**vhf**	very high frequency
FSN	federal stock number	**NC**	normally closed	**vlf**	very low frequency
g	gram	**(-) or neg**	negative	**W**	watt(s)
G	giga (10^9)	**NO**	normally open	**ww**	wire wound
gd	guard	**ns**	nanosecond	**xfmr**	transformer
Ge	germanium	**opnl ampl**	operational amplifier	**xstr**	transistor
GHz	gigahertz	**p**	pico (10^{-12})	**xtal**	crystal
gmv	guaranteed minimum value	**para**	paragraph	**xtlo**	crystal oscillator
gnd	ground	**pcb**	printed circuit board	**Ω**	ohm(s)
H	henry	**pF**	picofarad	**μ**	micro (10^{-6})
hd	heavy duty	**pn**	part number		

Federal Supply Codes for Manufacturers

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884
Use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp
Materials Systems Div.
New York, New York

05571
Use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
The Ross Milton Co.
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Div.
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, Massachusetts

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933
Use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

Federal Supply Codes for Manufacturers (cont)

08261
Spectra Strip Corp
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988
Use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc
Paso Robles, California

11358
CBS Electronic Div
Columbia Broadcasting System
Newburyport, Minnesota

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp
Rectifier Division
Hicksville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Div.
AMF Canada LTD.
Guelph, Ontario, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
The Budd Co. Polychem Products
Plastic Products Div.
Bridgeport, Pennsylvania

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc
Dallas, Texas

13327
Solitron Devices Inc
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp
Los Gatos, California

13606
Use 56289
Sprague Electric Co.
Transistor Div
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors,
formerly Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics
Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
GTE Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

Federal Supply Codes for Manufacturers (cont)

[illegible]
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical
Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp. formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, California

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnback Radio Co., Inc.
Freeport, New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

Federal Supply Codes for Manufacturers (cont)

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F , Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp.
Mepco Div.
A North American Phillips Co
Norristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183
Use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Arnold Stevens, Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
The Carr Co., United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp
Electric Power Div
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83478
Rubbercraft Corp.
of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
John Fluke Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

Federal Supply Codes for Manufacturers (cont)

90201
Mallory Capacitor Co.
Div. of P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211
Use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737
Use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div. of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div
Woburn, Massachusetts

94145
Replaced by 49956

94154
Use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

[illegible]
Gordo's Corp.
Bloomfield, New Jersey

[illegible]
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts, Div. of
Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

[illegible]
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

[illegible]
Sealectro Corp.
Mamaroneck, New York

[illegible]
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

[illegible]
Replaced by 14433

[illegible]
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Comp. Div.
formerly Southern Elect. Div.
Burbank, California

[illegible]
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

[illegible]
Use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

[illegible]
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

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Fluke Technical Center
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Edificia "Jerico"
Ave. 12 de Octubre #2285y
Ave. Orellana (Planta Baja)
Quito, Ecuador
Tel: 526759

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Hinditron Services Pvt. Ltd.
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THAILAND
Dynamic Supply Engineering R.O.P.
56 Ekamai, Sukhumvit 63
Bangkok-11, Thailand
Tel: 914434/928532

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Erkman Electronik Aletler
Ticaret Anonim Sirketi
Necatiby Cad 92/3
Karakoy, Istanbul, Turkey
Tel: 09-44-1-5461

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Watford, Herts. WD24TT
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Tel: 09-4492340511

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Edifico Ciudadela
Sarandi 690 D. Esc. 109
Casilla de Correos 1400
Correo Central
Montevideo, Uruguay
Tel: 917978

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Apdo. Postal 50939
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Section 4A
Manual Change Information

INTRODUCTION

This appendix contains information necessary to backdate the manual to conform with earlier pcb configurations. To identify the configuration of the pcb's used in your instrument, refer to the revision letter (marked in ink) on the component side of each pcb assembly. Table 4A-1 defines the assembly revision levels documented in this manual.

NEWER INSTRUMENTS

As changes and improvements are made to the instrument, the are identified by incrementing the revision letter marked on the affected pcb assembly. These changes are documented on a supplemental change/errata sheet which, when applicable, is inserted at the front of the manual.

OLDER INSTRUMENTS

To backdate this manual to conform with earlier assembly revision levels, perform the changes idicated in Table 4A-1.

CHANGES

There are no backdating changes at this printing. All pcb assemblies are documented at their original revision level.

Table 4A-1. Manual Status and Backdating Information

Ref Or Option No.	Assembly Name	Fluke Part No.	* To adapt manual to earlier rev configurations perform changes in desending order (by no.), ending with change under desired rev letter																						
			—	A	B	C	D	E	F	G	H	J	K	L	M	N	P								
A2	Mother PCB Assy.	421492	—	●	●	●	X																		
A3	CPU Module Assy.	495804	—	●	●	●	X																		
A4	DMA Floppy/Clock Module Assy.	493338	—	●	●	●	●	●	X																
A5	Memory Module Assy.	487090	—	—	—	—	—	●	●	●	X														
A6	Electronic Disk Module Assy.	493254	—	●	●	X																			
A7	Video/Keyboard Module Assy.	495770	—	●	●	●	●	●	●	●	●	X													
A8	IEEE-488 Interface Module Assy.	497420	—	—	—	●	●	●	●	X															
A9	Power Supply Module Assy.	493320	—																						
A9A1	P/S Control PCB Assy.	493429	—	●	●	●	●	●	●	●	●	●	●	X											
A9A2	P/S Rectifier PCB Assy.	493437	—	●	●	●	●	●	X																
A9A3	P/S Switching Transistor PCB Assy.	497826	—	●	●	●	X																		

* X = The PCB revision levels documented in this manual.
● = These revision letters were never used in the instrument.
— = No revision letter on the PCB.

Section 5
List of Replaceable Parts

TABLE OF CONTENTS

5-1. INTRODUCTION

5-2. This section contains parts breakdown of the instrument. Components are listed alphanumerically by assembly.

5-3. Parts lists include the following information:

1. Reference Designation.
2. Description of each part.
3. FLUKE Stock Number.
4. Federal Supply Code for Manufactures. (See Section 4 for Code-to-Name list.)
5. Manufacture's Part Number.
6. Total Quantity of components per assembly.
7. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of 2 years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for 1 year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked (see paragraph 5-7). In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended spares quantity for the items in that particular assembly.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. or it authorized representative by using the FLUKE STOCK NUMBER.

NOTE

Module assemblies must be ordered with the FLUKE STOCK NUMBER. Do not use the manufacturer's part number to order these assemblies.

In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

1. Quantity.
2. FLUKE Stock Number.
3. Description.
4. Reference Designation.
5. Printed Circuit Board Part Number and Revision Letter.
6. Instrument Model and Serial Number.

5-7. A Recommended Spare Parts Kit for your basic instrument is available from the factory. This kit contains those items listed in the REC QTY column of the parts list in the quantities recommended.

5-8. Parts price information is available from the John Fluke Mfg. Co., Inc. or its representative. Prices are also available in a Fluke Replacement Parts Catalog, which is available on request.

CAUTION

Indicated devices are subject to damage by static discharge.

Final Assembly 1720A Instrument Controller

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	1720A INSTRUMENT CONTROLLER (1720A-T&B/5001) THIS PARTS LIST IS AT PCB OR ASSEMBLY LEVELS, RECOMMENDED PARTS ARE LISTED FOLLOWING EACH ASSEMBLY.						
MP1	FLOPPY POWER CABLE	503003	89536	503003	1	1	
MP2	FOOT	544957	89536	544957	1	1	
MP3	CORD SET, 6A, 250V, 7-1/2 FT.	284174	89536	284174	1	1	
MP4	CORNER DECAL	296269	89536	296269	4	1	
MP5	DISKETTE 10-PACK	Y1706	89536	Y1706	1	1	
MP6	DIAGNOSTIC DISKETTE	521419	89536	521419	1	1	
MP7	SYSTEM DISKETTE	521401	89536	521401	1	1	
MP8	PROGRAMMER KEYBOARD	Y1720	89536	Y1720	1	1	
TM1	OPERATOR MANUAL	518647	89536	518647	1	1	
TM2	USER MANUAL	518654	89536	518654	1	1	
TM3	BASIC PROGRAMMING MANUAL	518670	89536	518670	1	1	
TM4	SERVICE MANUAL	518662	89536	518662	1	1	
TM5	PROGRAMMING WORK SHEET	533547	89536	533547	1	1	
TM6	BASIC PROGRAMMING REF GUIDE	526210	89536	526210	1	1	
TM7	HPL/BASIC MANUAL	546341	89536	546341	1	1	
A1	BEZEL ASSEMBLY (1720A-4202T)	SEE	NOTE	*	1		
	CRT KIT (CRT & ELECTRONICS) (1720A-7640K)	577379	89536	537472	1	1	
	TOUCH SENSE PANEL	483644	89536	483644	1	1	
A1A1	FRONT PANEL PCB ASSEMBLY (1720A-4008)	493445	89536	493445	1	1	
A2	MOTHER PCB ASSEMBLY (1720A-4002T)	421492	89536	421492	1	1	
A3	CPU MODULE ASSEMBLY (1720A-7604K)	577320	89536	495804	1	1	
	HDT PROM, EVEN BYTE	576322	89536	576322	1	1	
	HDT PROM, ODD BYTE	576314	89536	576314	1	1	
	STANDARD PROM 2708 ODD BYTE	495796	89536	495796	1	1	
	STANDARD PROM 2708 EVEN BYTE	495788	89536	495788	1	1	
	(NOTE: ODD BYTE PROM MOUNTS CLOSEST TO MICROPROCESSOR.)						
	IC, N-CHAN, MICROPROCESSOR	473249	01295	TMS9900	1	1	
A4	DMA FLOPPY/CLOCK MODULE ASSEMBLY (1720A-7614K)	577361	89536	493338	1	1	
U12	IC, DIG. CLOCK CHIP, 4-CTR	507756	07263	FCM6020	1	1	
U15	IC, DMA CONTROLLER	504316	52840	DM1883B	1	1	
U16	IC, FLOPPY DISK CONTROLLER	504308	52840	FD1791B	1	1	
Y1	CRYSTAL, 32.768 HZ	501817	51791	CX-1V-32.768HZ	1	1	
A5	MEMORY MODULE ASSEMBLY (1720A-7603K)	577312	89536	487090	1	1	
U19 THRU U27 U33 THRU U41 U46 THRU U54 U59 THRU U67	IC, MEMORY	483487	01295	TMS4116-25NL	36	7	
U57	IC, DIGITAL	483529	34649	D3242	1	1	

Final Assembly 1720A Instrument Controller (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A6	ELECTRONIC DISC (SPARE) (1720A-4017T/-001)	518472	89536	OPTION 001 **	AR	1	
S1	SWITCH, DIP, 4-POS	408559	10582	206-4	1	1	
U4	IC, ADDRESS MUX & REFRSH CTR	483529	34649	D3242	1	1	
U10, U13 U18 THRU U21 U26 THRU U29 U34 THRU U37 U42 THRU U45 U50 THRU U53 U58 THRU U61 U66 THRU U69 U73 THRU U76	IC, RAM MEMORY	523654	50088	MK4332D-2	36	7	
Y1	CRYSTAL, 10 MHZ, 10 PPM	385732	09579	183025B	1	1	
A7	VIDEO/KEYBOARD MODULE ASSEMBLY (1720A-7609K)	577346	89536	495770	1	1	
J24	PHONO JACK, RIGHT ANGLE	500819	11503	901	1	1	
U10,U28	IC, DIGITAL	483552	01295	TMS9902NL	2	1	
U36	IC, DIG., GENERATOR	534776	04713	MCM66740	1	1	
U41	IC, DIGITAL	483503	34649	C8275	1	1	
U42	IC, DIGITAL	504332	01295	TMS9981N	1	1	
U47	PROGRAM ROM	535032	89536	535032	1	1	
S2	SWITCH, SLIDE	452862	89536	452862	1	1	
Y1	CRYSTAL, 10 MHZ	520239	89536	520239	1	1	
A8	IEEE-488 INTERFACE MODULE ASSEMBLY (1720A-7613K)	577353	89536	497420	1	1	
J1	RECEPT, CONNECTOR	485763	00779	552791-2	1	1	
J2	RECEPT, CONNECTOR	500884	00779	552791-1	1	1	
MP1	BRACKET, CONN. SUPPORT	545616	89536	545616	1	1	
MP2	BRACKET, GROUND	545624	89536	545624	1	1	
S1,S2	SWITCH ASSY., DIL, 8-POS, SPDT	404490	00779	435166-5	2	1	
S3	SWITCH, SLIDE (BLACK)	393629	10389	23-021-114	1	1	
A9	POWER SUPPLY MODULE INCLUDES A9A1, A9A2, A9A3 (1720A-7630K)	577338	89536	493320	1	1	
B1	BATTERY, 4 AMP HR., 6V	501379	56309	PS640	1	1	
MP1	AIR FILTER	524660	89536	524660	1	1	
A9A1	POWER SUPPLY CONTROL PCB ASSEMBLY (1720A-4006)	493429	89536	493429	1	1	
F1	FUSE, SLO-BLO, 3 AMP, 250V	109280	71400	MDA3	1	5	
MP1	INSTRUMENT FOOT	544957	89536	544957	2	2	
MP2	LINE FILTER	500405	89536	500405	1	1	
MP3	FAN ASSEMBLY	501312	89536	501312	1	1	
MP4	CAP, (TO XF1 FUSEHOLDER)	460238	89536	460238	1	1	
XF1	FUSE HOLDER W/NUT (F1)	460329	89536	460329	1	1	
S1	SWITCH, ROCKER, 3-POLE (CODE 3)	513838	73559	T1HL50-1L-BL-FNBL	**	1	
S1	SWITCH, ROCKER, 2-POLE (CODE 4)	542720	73559	T1GL50-1L-BL-FNBL	AR	1	

Final Assembly 1720A Instrument Controller (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A9A2	POWER SUPPLY RECTIFIER ASSEMBLY (1720A-4007)	493437	89536	493437	1	1	
CR14	DIODE, RECTIFIER, 3 AMP	524231	04713	MBR-320M	1	1	
F1	FUSE, 5 AMP, 250V	109215	71400	MDA5	1	5	
K1	RELAY	512574	82227	28D111ZE-0231	1	1	
MP1	BUTTON, POWER SWITCH	545814	89536	545814	1	1	
Q1,Q2	XSTR, SI, NPN	418459	01295	TIP-31	2	1	
S1	SWITCH, SLIDE	453365	79727	G1-116-0005,G-20-32	1	1	
U4	IC, LIN, NEG. VOLT REGULATOR	394551	04713	MC7905CP	1	1	
A9A3	TRANSISTOR SWITCHING ASSEMBLY (1720A-4016)	SEE	NOTE	*	1	1	
Q1,Q2	XSTR, SI, NPN, POWER	495705	04713	MJ10007	2	1	
Q3,Q4	XSTR, SI	495697	04713	MPS-U06	2	1	
Q5,Q6	XSTR, SI	495689	04713	MPS-U56	2	1	
A10	FLOPPY DISK REPLACEMENT MODULE (1720A-7635K)	521393	89536	500488	1	1	
	FIELD SERVICE KITS						
	#1 CRT KIT	577379	89536	537472 **	AR	1	
	#3 SERVICE KIT (MODULE)	537506	89536	537506 **	AR	1	
	70% LEVEL KIT (PARTIAL)	539361	89536	539361 **	AR	1	
	ACCESSORIES						
	1 EXTENDER CARD	Y1704	89536	Y1704 **	AR	1	
	2 NULL MODEM ADAPTER	Y1705	89536	Y1705 **	AR	1	
	3 2M RS-232 CABLE	Y1707	89536	Y1707 **	AR	1	
	4 10M RS-232 CABLE	Y1708	89536	Y1708 **	AR	1	
	5 2M RS-232 PRINTER CABLE	Y1709	89536	Y1709	AR	1	
	6 SHIPPING CASE	Y1711	89536	Y1711 **	AR	1	
	7 RACK MOUNT KIT	Y1790	89536	Y1790 **	AR	1	
	8 MAINTENANCE KIT	577791	89536	577791	AR	1	

* NON-PROCURABLE AT ASSEMBLY LEVEL

** AR = CUSTOMER OPTION

Section 6
Schematics

TABLE OF CONTENTS

Bus Signals				
NAME	**MNEMONIC**	**NUMBER OF LINES**	**TYPE OF DRIVER**	**ACTIVE LEVEL**
Address Bus	A00-A19	20	Tri-State Buffer	High
Data Bus	DI00-DI15	16	Tri-State Buffer	High
CRU Bus				
CRU Input	CRIN	1	Open Collector	High
CRU Output	CROUT	1	TTL Buffer	High
CRU Clock	CRCLK-	1	TTL Buffer	Low
CRU Address Acknowledge	CRACK-	1	Open Collector	Low
Control Bus				
Address Valid	ACVAL-	1	Tri-State Buffer	Low
Address Acknowledge	ADACK-	1	Open Collector	Low
Bus Write	BUSWR-	1	Tri-State Buffer	Low
Refresh-Interrupt	RINT-	1	Tri-State Buffer	Low
Bus Request In	RQIN-	1	TTL	Low
Bus Request Out	RQOUT	1	TTL	Low
Bus Grant In	GRIN	1	TTL	Low
Bus Grant Out	GROUT-	1	TTL	Low
Clock Sync	SYNC	1	TTL Buffer	N/A
Byte Mode	BMODE	1	TTL	Low
Hardware Error	HERR-	1	Open Collector	Low
Bus Clear	BCLR-	1	TTL Buffer	Low
ACOK	ACOK	1	TTL Buffer	High
DCOK	DCOK	1	TTL Buffer	High
Test	TEST-	1	TTL Buffer	Low
Halt	HALT-	1	Open Collector	Low
Power Supply Lines				
+5 Volts	+5V	2		
+12 Volts	+12V	2		
Logic Common	LCOM	8		
-12 Volts	-12V	1		
Battery Backed Up Supplies				
+5 Volts	+5VB	1		
-5 Volts	-5VB	1		
+12 Volts	+12VB	1		

Bus Signal Definitions	
SIGNAL NAME	**DEFINITION**
ADDRESS BUS	(A00-A19) - 20 lines used by the processor and Direct memory Access (DMA) devices to address a word of memory or an I/0 Register. The lower 12 bits (A00-A11) are also used for Communications Register Unit (CRU) addressing.
DATA BUS	(DI00-DI15) - 16 lines for data transfer throughout the system. In addition, when the Refresh-Interrupt control line is asserted, a device requests interrupt service by driving its assigned data bus line to the low (logic 0) state. Interrupts are prioritized with a request on data bit 0 (DI00) having the highest priority and data bit 15 (DI14) the lowest. Only one interrupting device is allowed per line.
ADDRESS VALID	(ADVAL-) - Indicates the presence of valid address information on the address bus. Also indicates that data on the DATA/INTERRUPT lines is true during processor write operations.

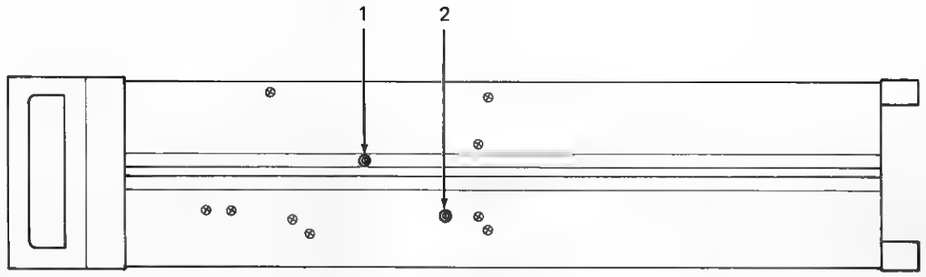
Figure 6-1. List of Mnemonics and Bus Signal Definitions

SIGNAL NAME	DEFINITION
ADDRESS ACKNOWLEDGE	(ADACK–) - Response line from an addressed memory or I/0 device. Must be asserted to indicate address recognition and allow processor (or DMA device) to procees with I/0 or memory operation.
BUS WRITE	(BUSWR–) - Indicates direction of data transfer on DATA/INTERRUPT lines. A low level indicates that processor (or DMA device) is sending data to the address I/0 or memory register.
REFRESH-INTERRUPT	(RRINT–) When asserted, indicates that interrupting devices may request interrupt service by driving the appropriate data line low. Dynamic memory devices use this line to initiate a refresh cycle.
BUS REQUEST IN	(RQIN–) - Active low request by device which wishes to control the bys (typically a high speed I/0 device). This line changes at each connector. It is called Bus Request Out (RQOUT–) as it leaves the connector, having passed through the device installed in that connector. From this connector, the line goes to the next higher priority device (closer to processor) where it will again be called Bus Request In (the processor has only a RQIN- line). The device which is physically closest to the processor has the highest request priority. Each device inhibits transfer of the RQIN signal to the RQOUT line if and only if it is also requesting the bus and no lower priority device has been granted the bus, signified by a low logic level on Bus Grant In (GRIN–).
BUS REQUEST OUT	(RQOUT–) - Active low signal to signify that a device is requesting control of the bus. This line will be asserted by the device to request bus usage or if the Bus Request In line is asserted. A device may not request the use of the bys if it has already been granted to a lower priority device signified by a low level on Bus Grant In. See also Bus Request In. A non-DMA device should connect Bus Request In to Bus Request Out to maintain continuity through the device.
BUS GRANT IN	(GRIN–)-Active low indication that the processor has places its tri-state bus drivers in the high impedance mode and entered the hold state. This line is broken at each connector and is called Bus Grant Out (GROUT–) as it leaves each device enroute to the next lower priority devie (further from processor), where it is called Bus Grant In.
BUS GRANT OUT	(GROUT–) - Each device normally transfers the logic state of the Bus Grant In line to the Bus Grant Out line. A device inhibits this transfer only when it is requesting or has been granted control of the bus. At this time, the Bus Grant Out line is maintained at a logic high level. Non-DMA devices shouldconnect Bus Grant In to Bus Grant Out to maintain continuity of the grant signal.
CLOCK SYNC	(SYNC) - Six megahertz clock.
BUS CRU INPUT	(CRIN) - communications Register Unit (CRU) input line, sampled during execution of the Store Communications Register (STCR) and Test Bit (TB) instructions.
BUS CRU OUTPUT	(CROUT) - CRU output line. Serial data is placed on this line during execution of the Load Communication Register (LDCR), Set Bit to Zero (SBZ), and Set Bit to One (SBO) instructions. Data is valid when the CRU clock line is low.
CRU ADDRESS ACKNOWLEDGE	(CRCLK–) - Active low indication that valid data appears on the CROUT line. (CRACK–) - Active low response line from addressed CRU devices. Must be asserted by CRU device when its address is placed on the address bus.
HARDWARE ERROR	(HERR–) - Active low line indicates that a device has detected a fatal error, such as a memory parity error, during a read or refresh operation. Assertion of this line will initiate a processor load sequence immediately following the instruction being executed.
BUS CLEAR	(BCLR–) - A low level on this line indicates that the bus interface circuitry on all devices should be reset to the unaddressed and inactive state. BDLR- is active for 160 ns.
ACOK	(AC OK) - A high level indicates that the unit is receiving adequate ac power. A transition from the high to low state indicates that the unit may soon lose dc power and backup operations should commence.

Figure 6-1. List of Mnemonics and Bus Signal Definitions (cont.)

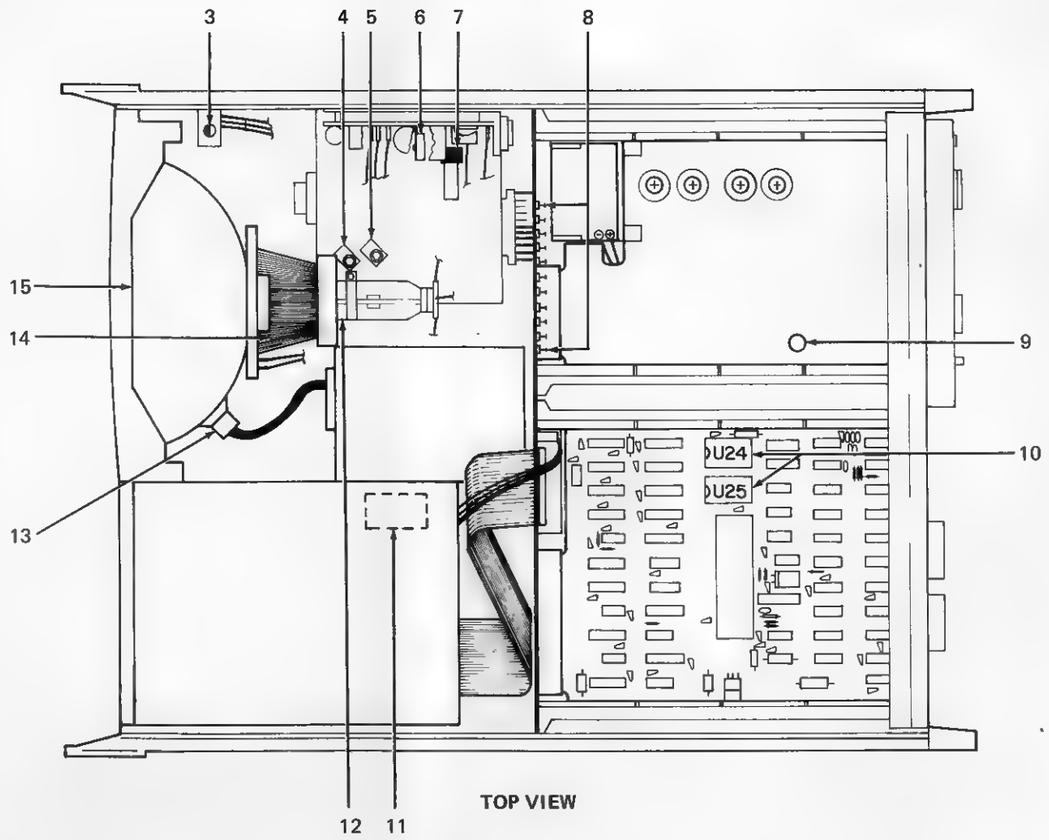
SIGNAL NAME	DEFINITION
BYTE MODE	(BMODE) - A low level indicates that the bus master is expecting data in byte format. DI08 through DI15 contain valid data. DI00 through DI07 are not used.
DCOK	(DC OK) - This line is intended for use as a power on/off reset. When this line as low all operation in the unit umst cease since the power supplies are close to falling out of regulation. The only exception will be circuitry capable of rumming off the battery supply (BATT).
TEST	(TEST-) - This signal enables those devices with special diagnostic circuits to enter a special mode of operation.
HALT	(HALT-) - This active low line will initiate a load sequence.

Figure 6-1. List of Mnemonics and Bus Signal Definitions (cont.)

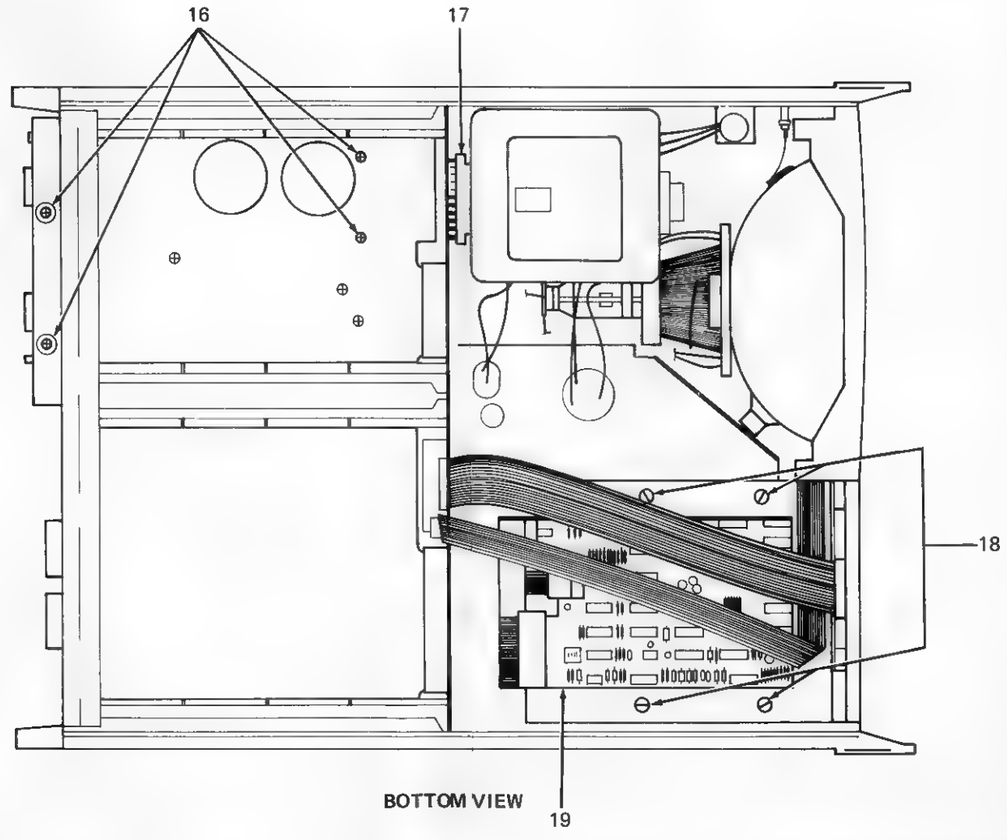


SIDE VIEW

ITEM NO.	NAME	ITEM NO.	NAME
1	Horizontal Osc Coil (L50)	11	Disk Drive Power Connector (on PCB)
2	Horizontal Size Coil (L53)	12	Yoke centering rings
3	Raster Pot on the chassis bracket	13	CRT HV Lead
4	Vertical Linearity Pot	14	CRT Yoke
5	Vertical Size	15	CRT
6	Focus Pot	16	Four screws that hold the Power Supply PCB to the rest of the Power Supply.
7	Master Brightness Pot in the CRT Electronics Area (on vertical PCB).	17	CRT Electronics Assembly Edge Connector
8	TP1 through TP11 (labeled on Mother Board)	18	Four screws that pass through the bottom mounting plate into the Floppy Disk Drive Unit Cover.
9	5V Adjust Pot	19	Floppy Disk Drive PCB
10	PROMs		



TOP VIEW



BOTTOM VIEW

Figure 6-2. Top, Bottom and Side Views

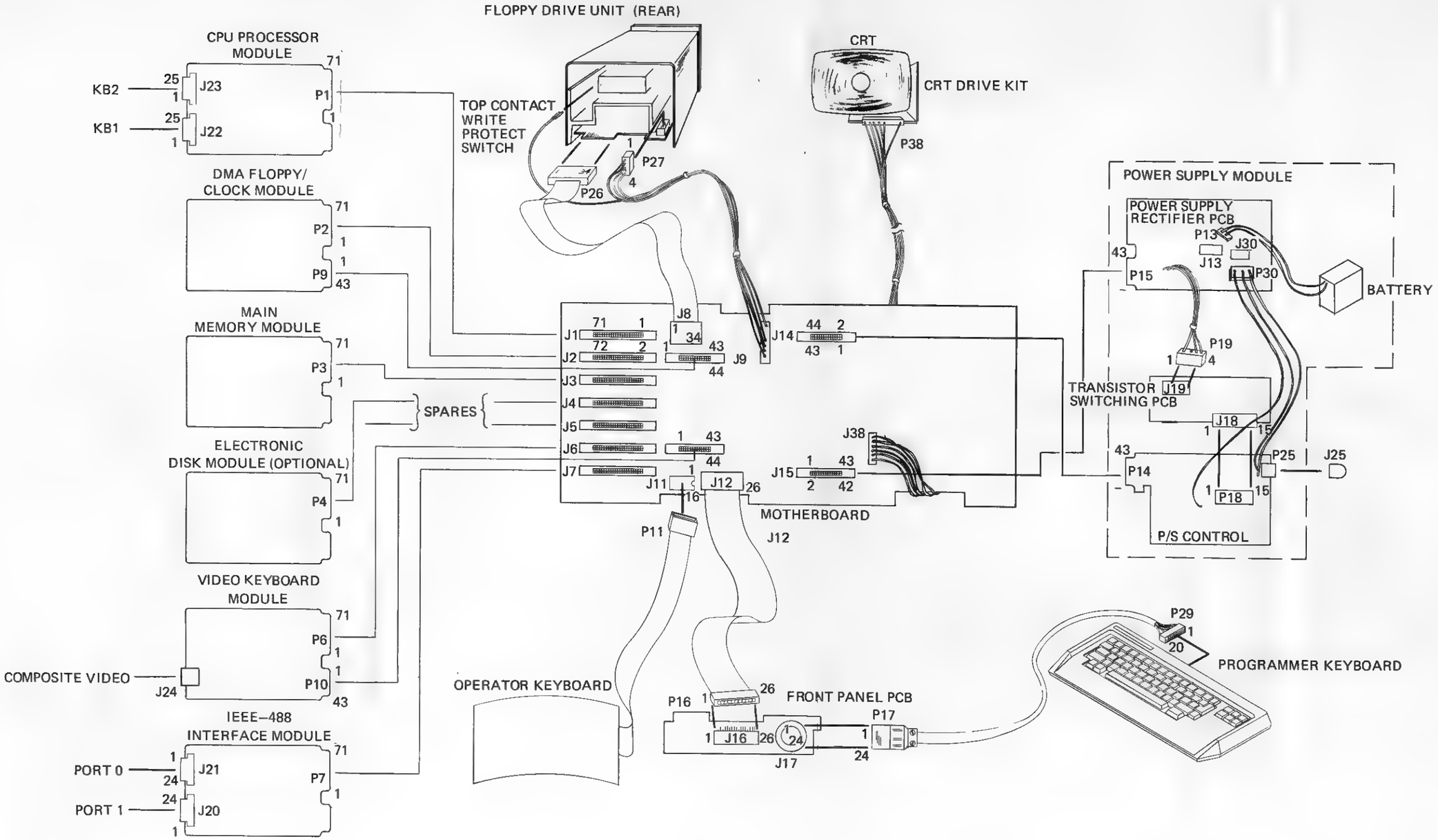


Figure 6-3. Interconnection Diagram

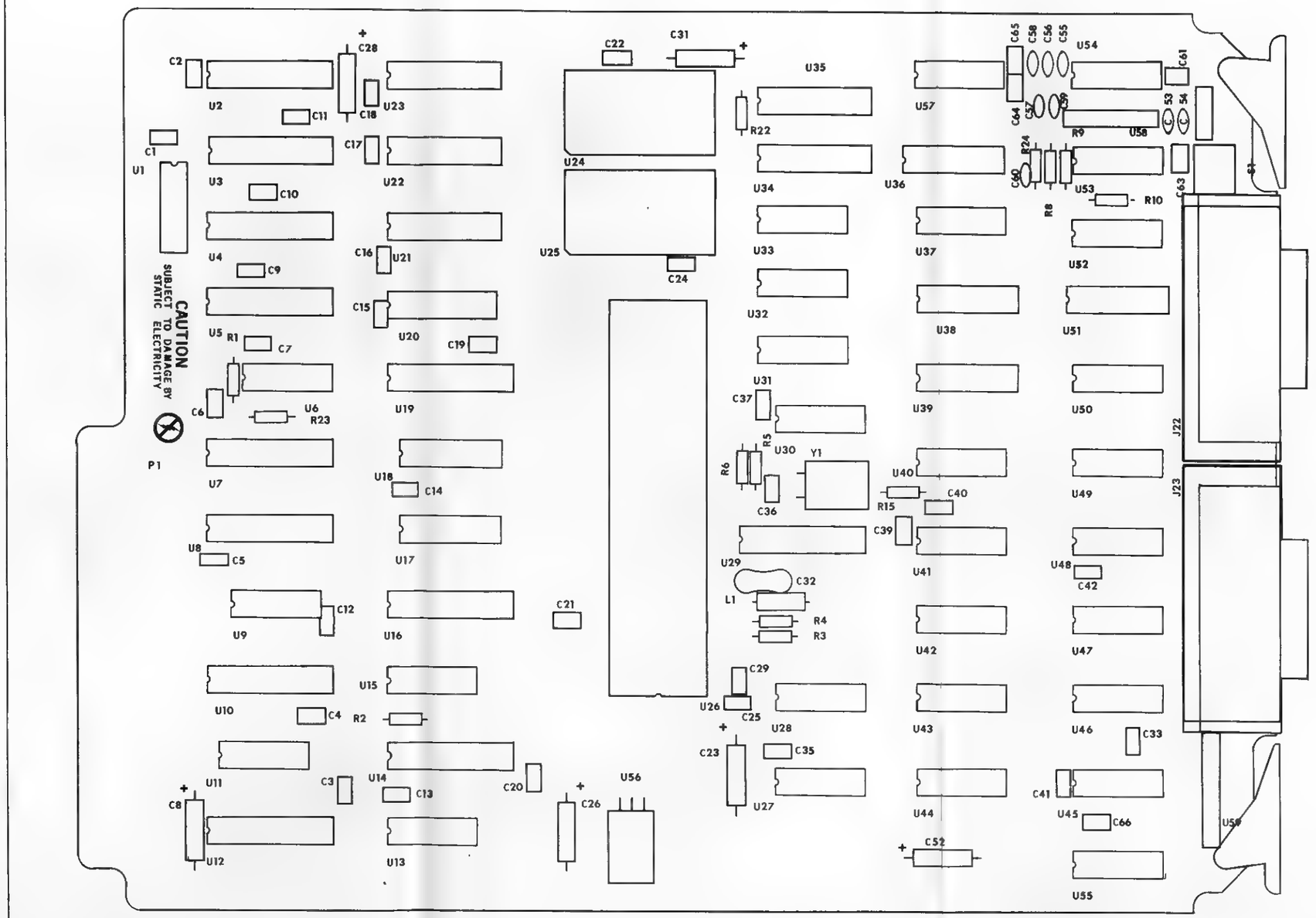


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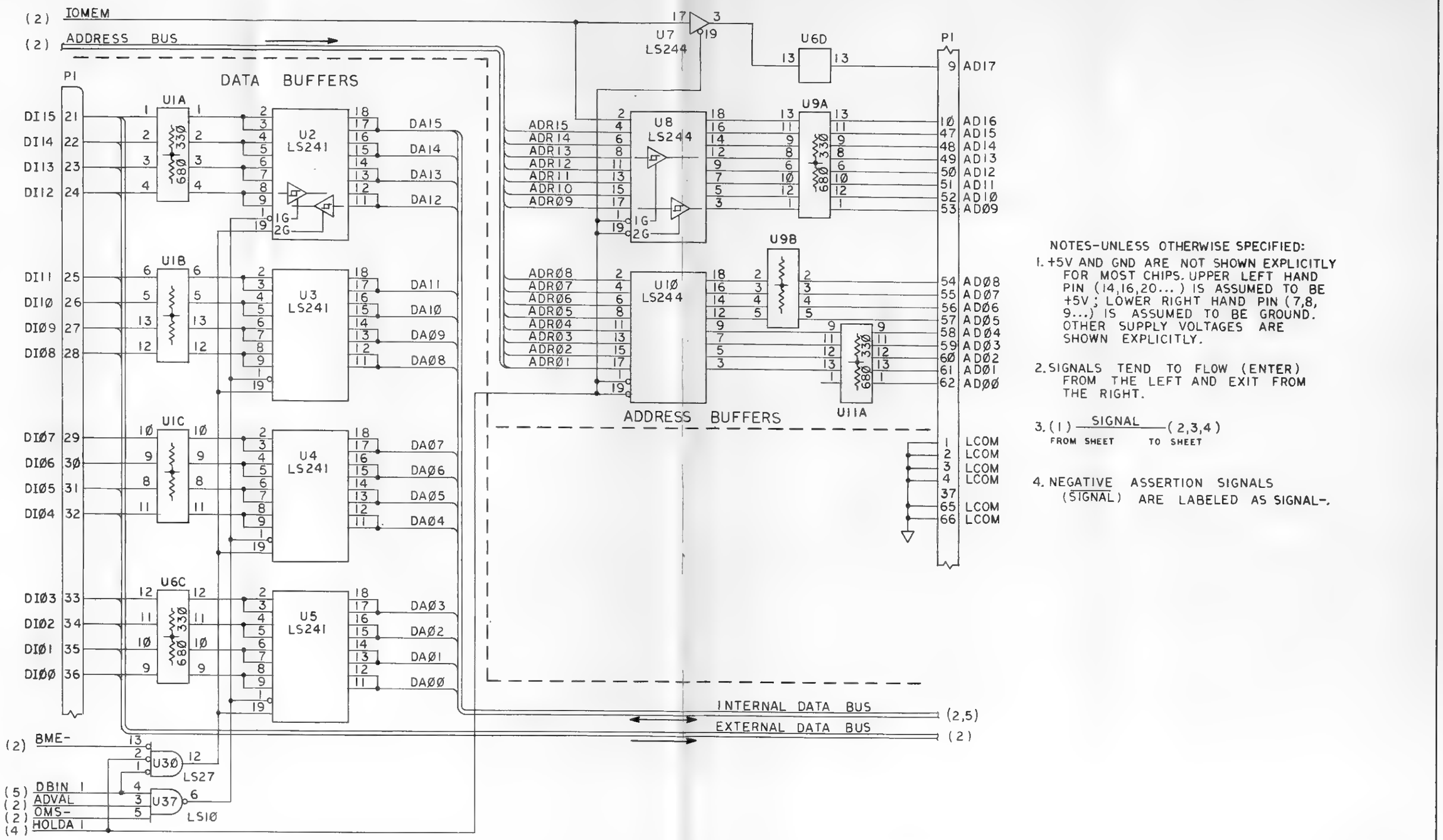
Figure 6-4. CPU Module Assembly



NOTES-UNLESS OTHERWISE SPECIFIED:

1. +5V AND GND ARE NOT SHOWN EXPLICITLY FOR MOST CHIPS. UPPER LEFT HAND PIN (14,16,20...) IS ASSUMED TO BE +5V; LOWER RIGHT HAND PIN (7,8, 9...) IS ASSUMED TO BE GROUND. OTHER SUPPLY VOLTAGES ARE SHOWN EXPLICITLY.

2. SIGNALS TEND TO FLOW (ENTER) FROM THE LEFT AND EXIT FROM THE RIGHT.

3. (1) SIGNAL (2,3,4)
FROM SHEET TO SHEET

4. NEGATIVE ASSERTION SIGNALS (SIGNAL) ARE LABELED AS SIGNAL-.

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Figure 6-4. CPU Module Assembly (cont.)

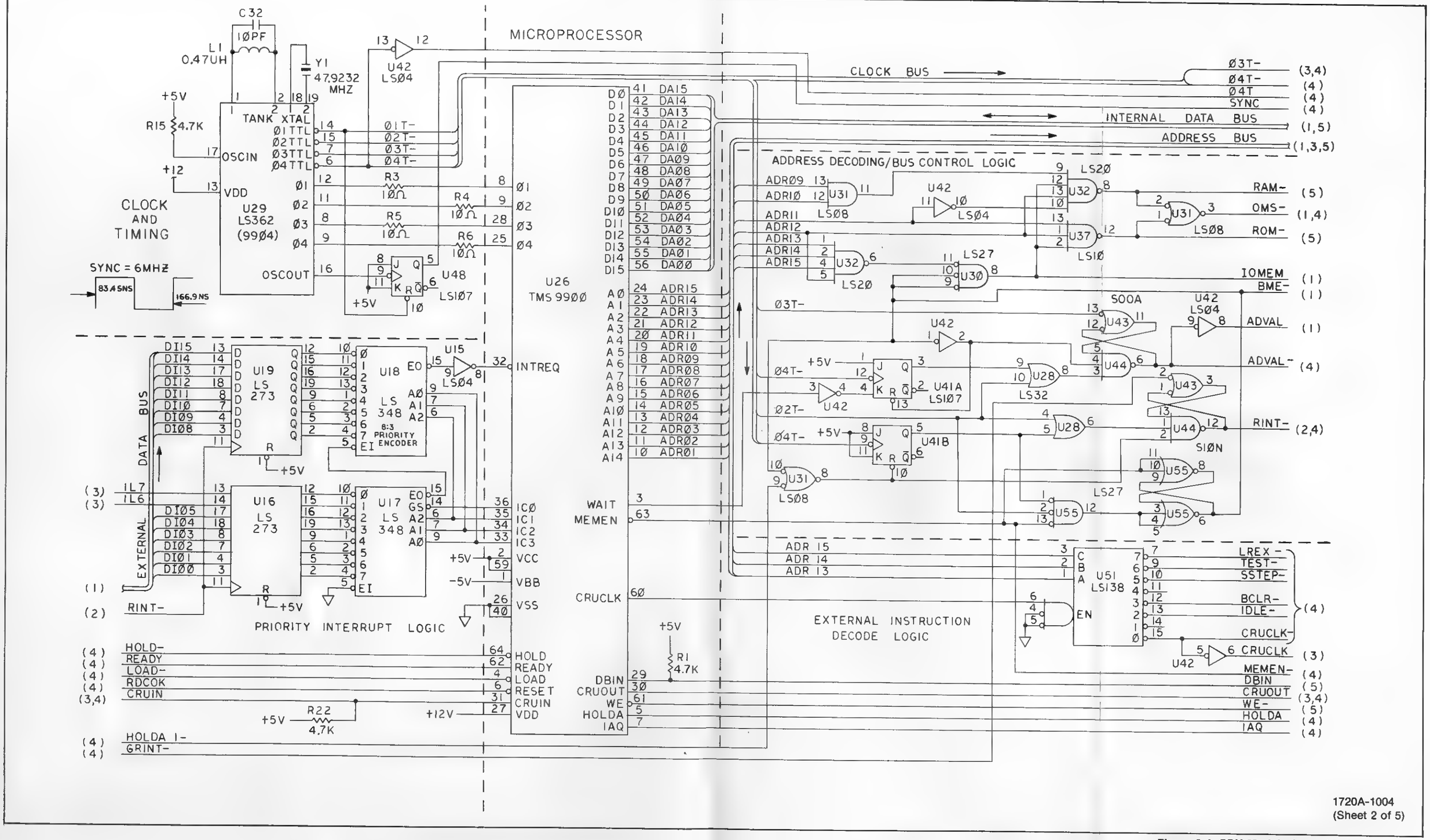

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Figure 6-4. CPU Module Assembly (cont.)

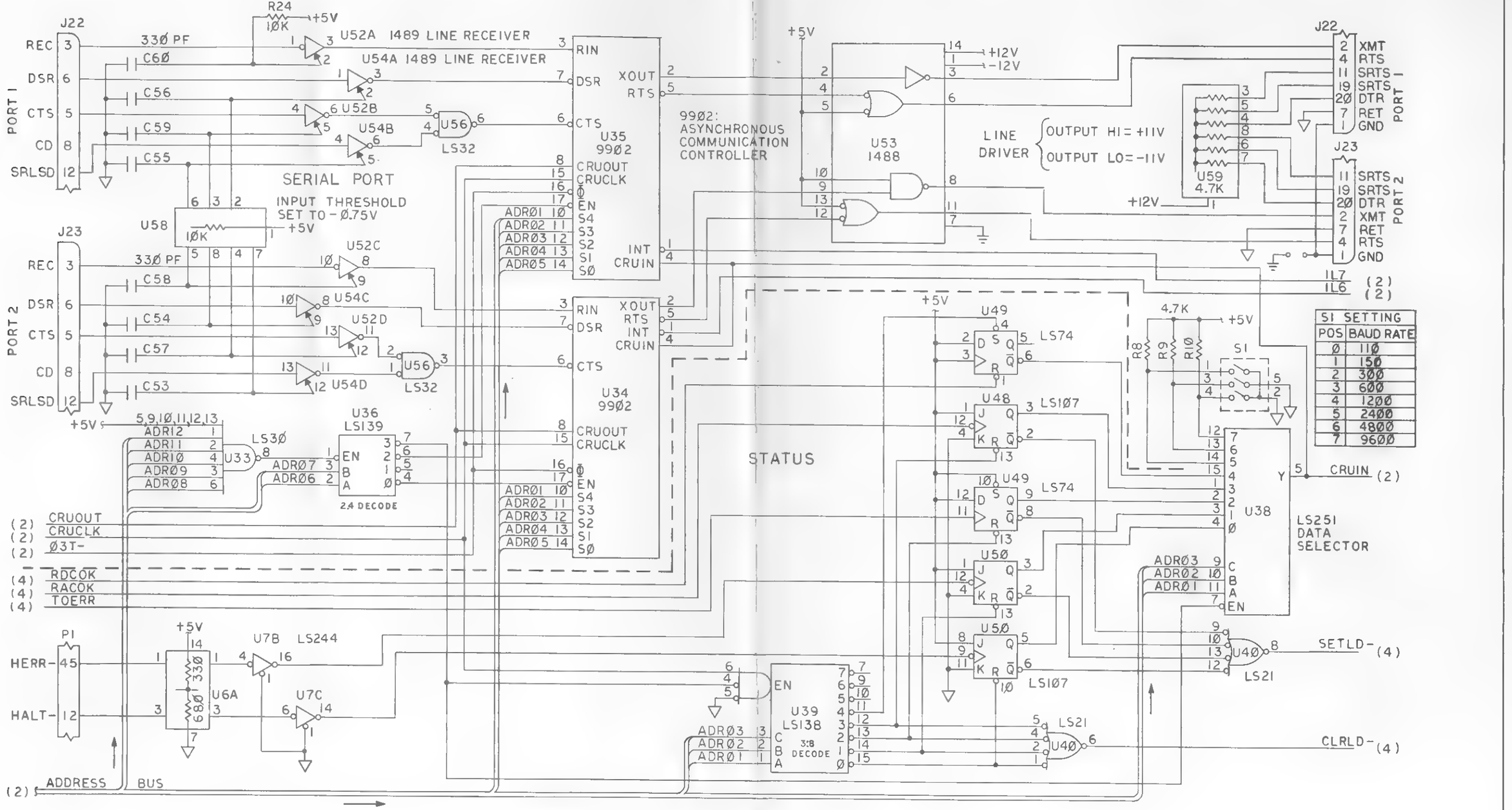

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Figure 6-4. CPU Module Assembly (cont.)

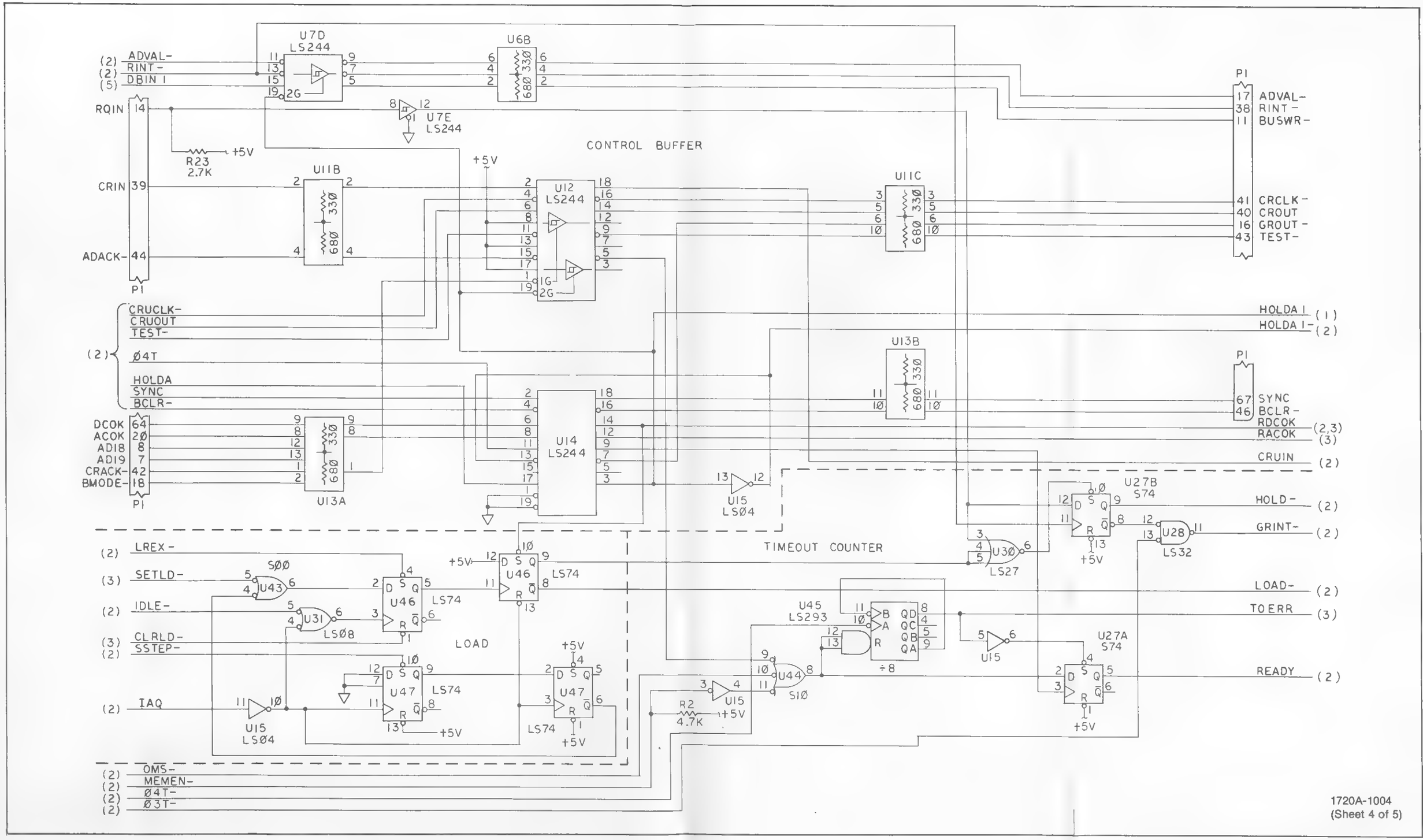

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Figure 6-4. CPU Module Assembly (cont.)

ROM

SCRATCHPAD RAM

INTERNAL DATA BUS

(2) ADDRESS BUS

(1,2)

U25 2708

U24 2708

U23 2111

U22 2111

U21 2111

U20 2111

(2) ROM-

+12V

-5V

+5

VBB

VDD

VCC

VSS

LS244 U7C

LS04 U15

(2) DBIN

(2) WE-

(2) RAM-

DBIN 1

(1,4)

U56 7905

-12V

+12V

+5V

C22,C25 .22UF

C26 68UF 15V

C66 .22UF

C8 C23 C28 C31 100UF/10V

C1-C7,C9-C21,C24,C29,C33,C35-C36,C40-C42,C61,C63,C65

BYPASS CAPS .22UF

C52 68UF 15V

C37,C39,C64 .22UF

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Figure 6-4. CPU Module Assembly (cont.)

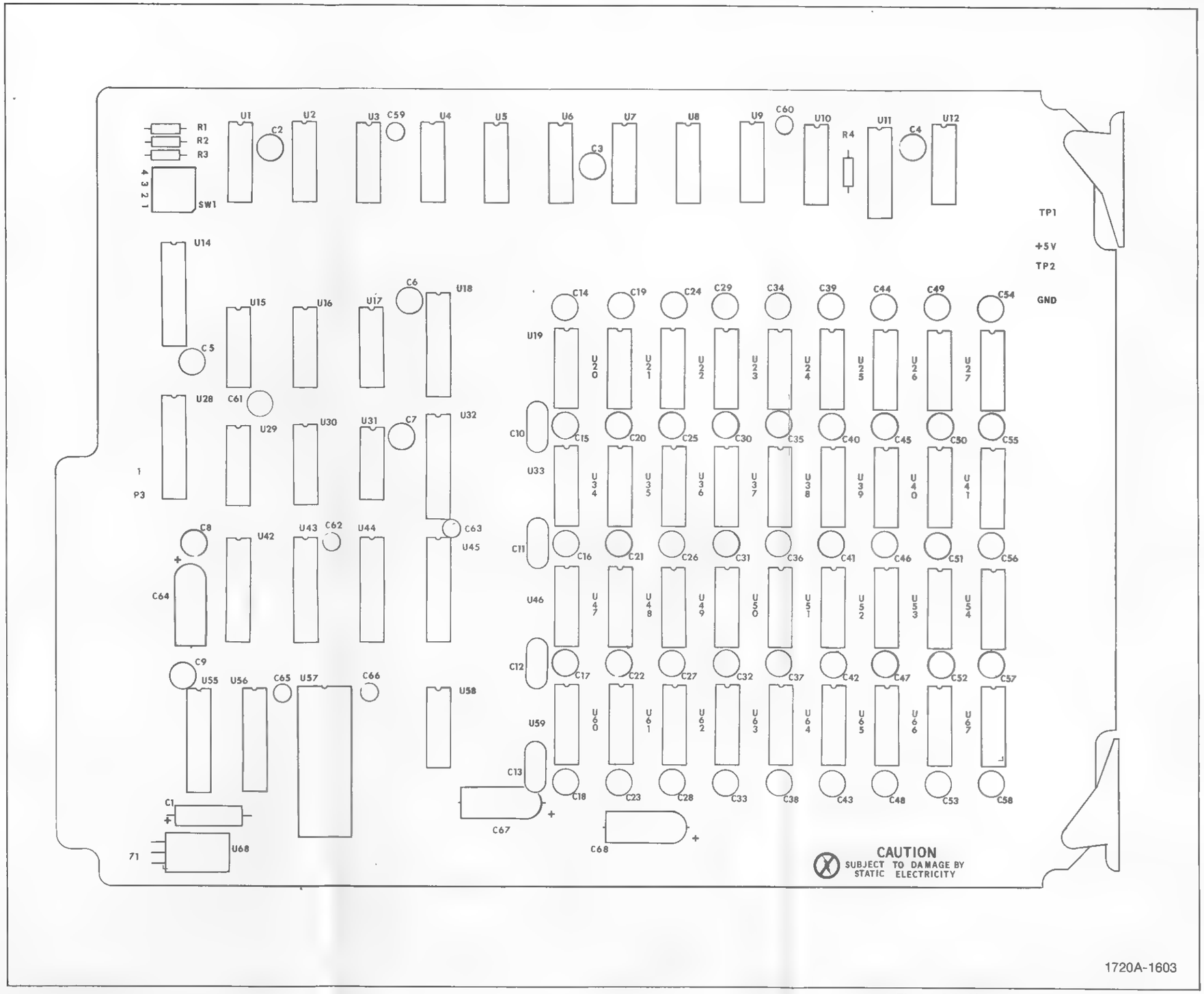

Figure 6-5. Memory Module Assembly

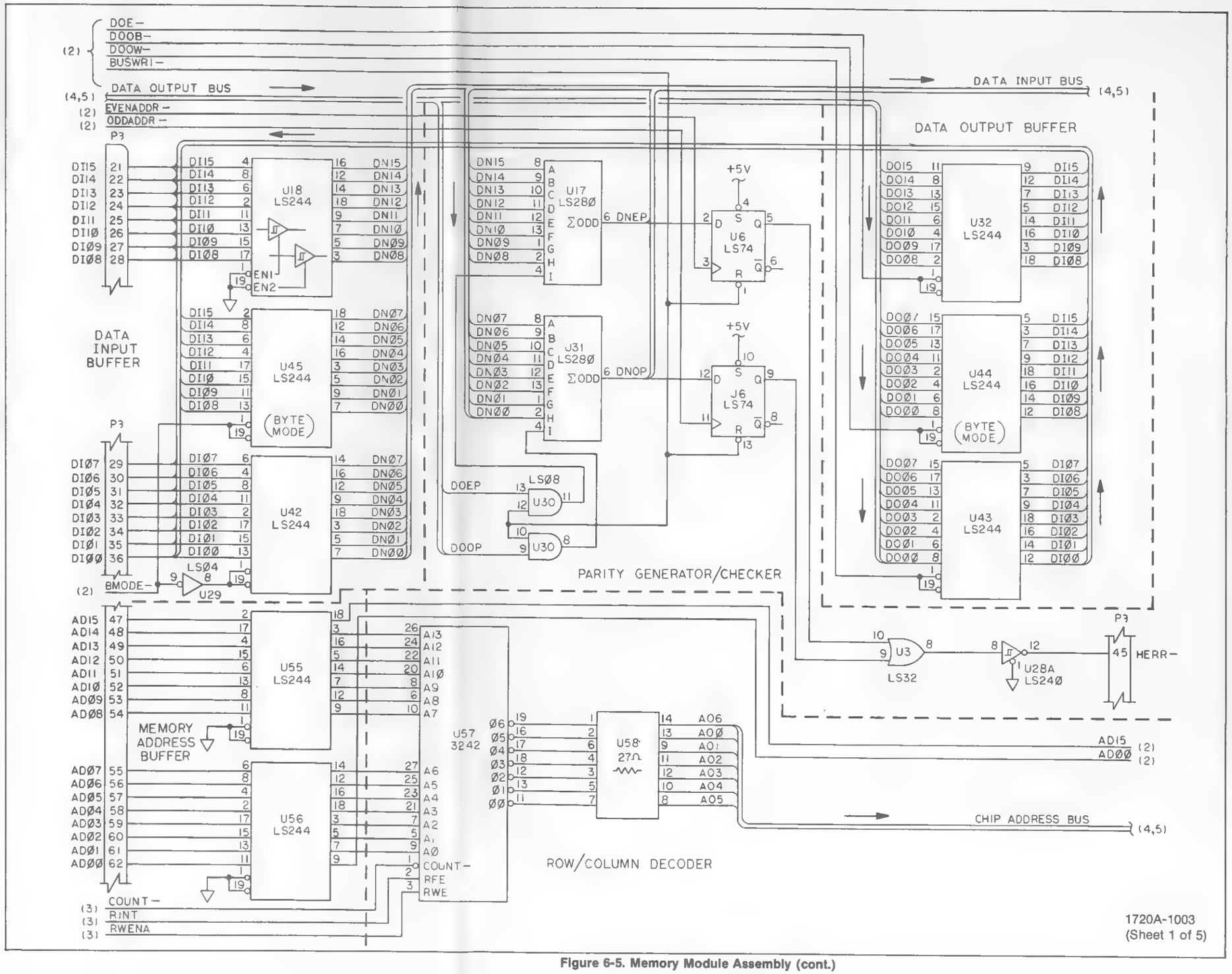

Figure 6-5. Memory Module Assembly (cont.)

BYTE/BANK DECODER

MEMORY MANAGED SYSTEMS					
BOARD	ADDR. SPACE	S2	S1	AD17	AD16
1	00000 0FFFF	ON	ON	0	0
2	10000 1FFFF	OFF	ON	0	1
3	20000 2FFFF	ON	OFF	1	0
4	30000 3FFFF	OFF	OFF	1	1
S3: ON=HALF BOARD, OFF=FULL BOARD					
S4: NOT USED					

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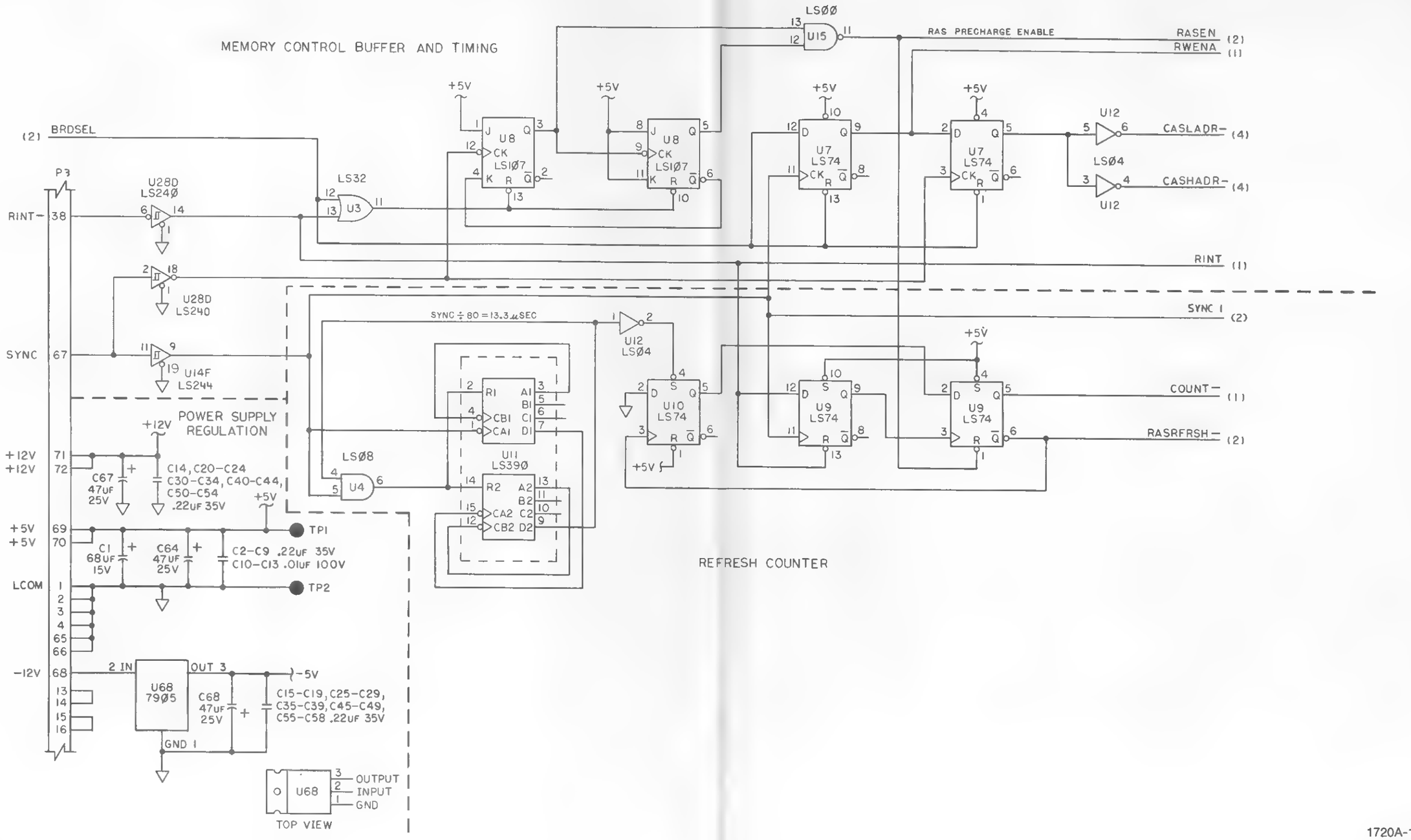
(Sheet 2 of 5)

Figure 6-5. Memory Module Assembly (cont.)



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(Sheet 3 of 5)

Figure 6-5. Memory Module Assembly (cont.)

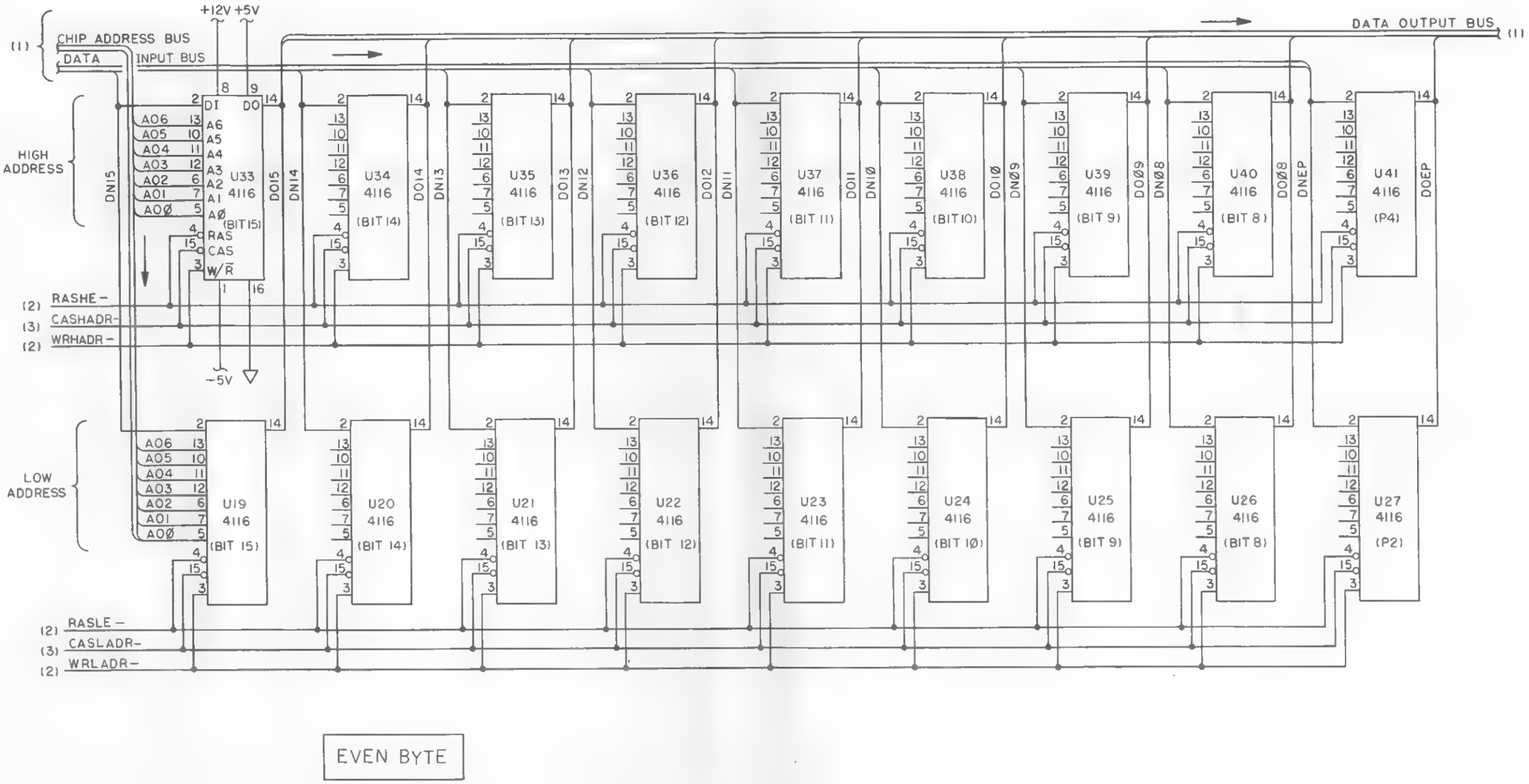

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Figure 6-5. Memory Module Assembly (cont.)

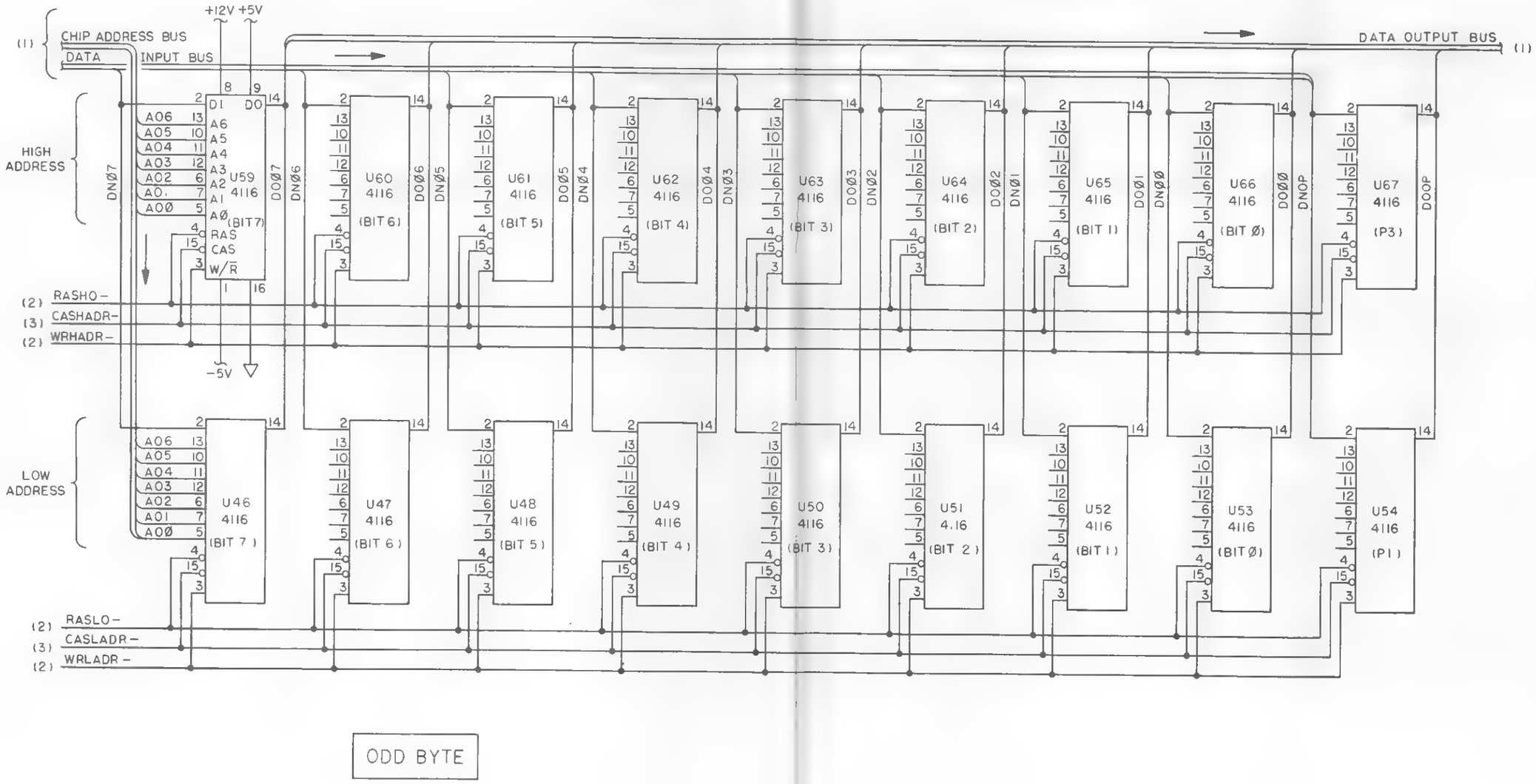

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Figure 6-5. Memory Module Assembly (cont.)

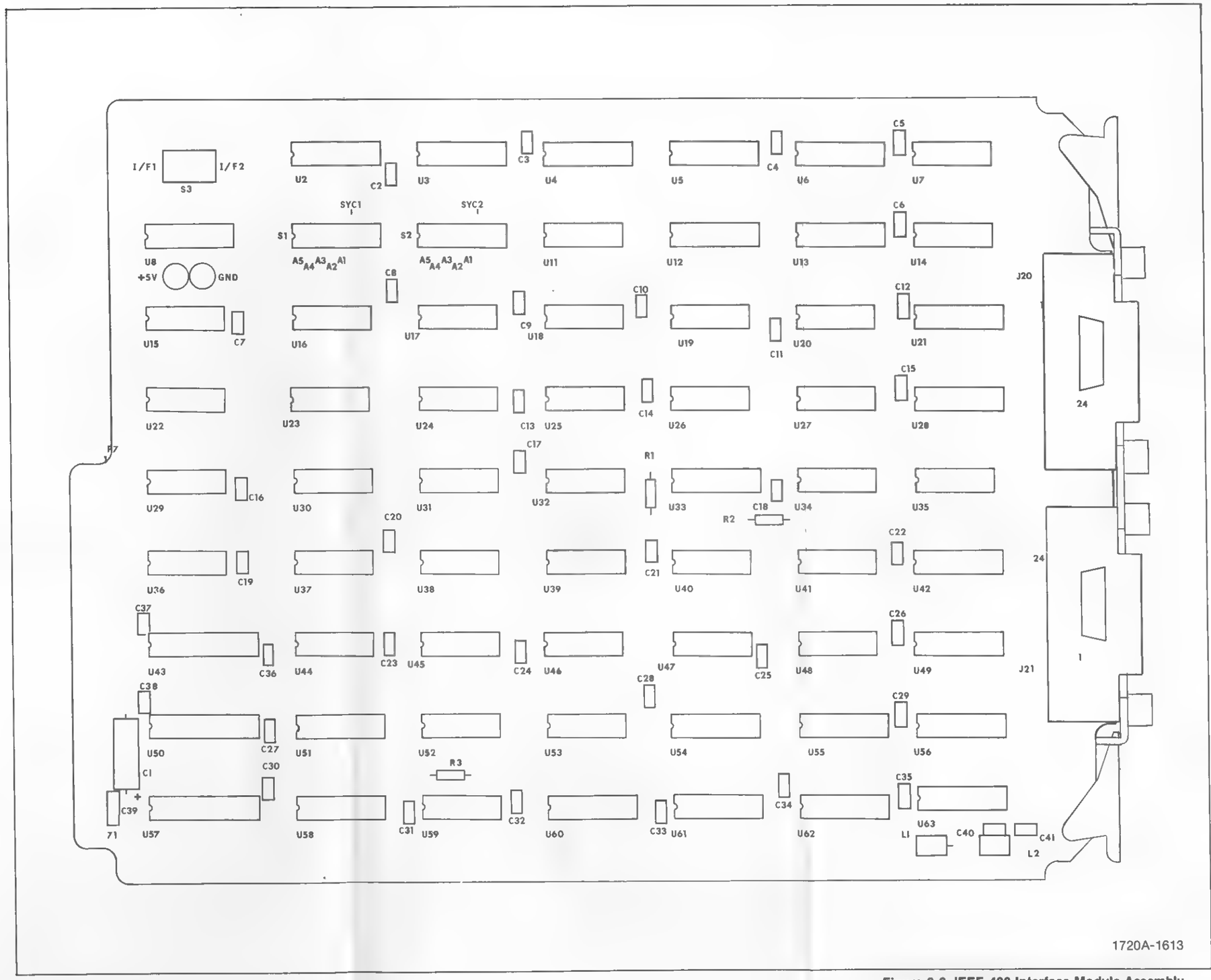

Figure 6-6. IEEE-488 Interface Module Assembly

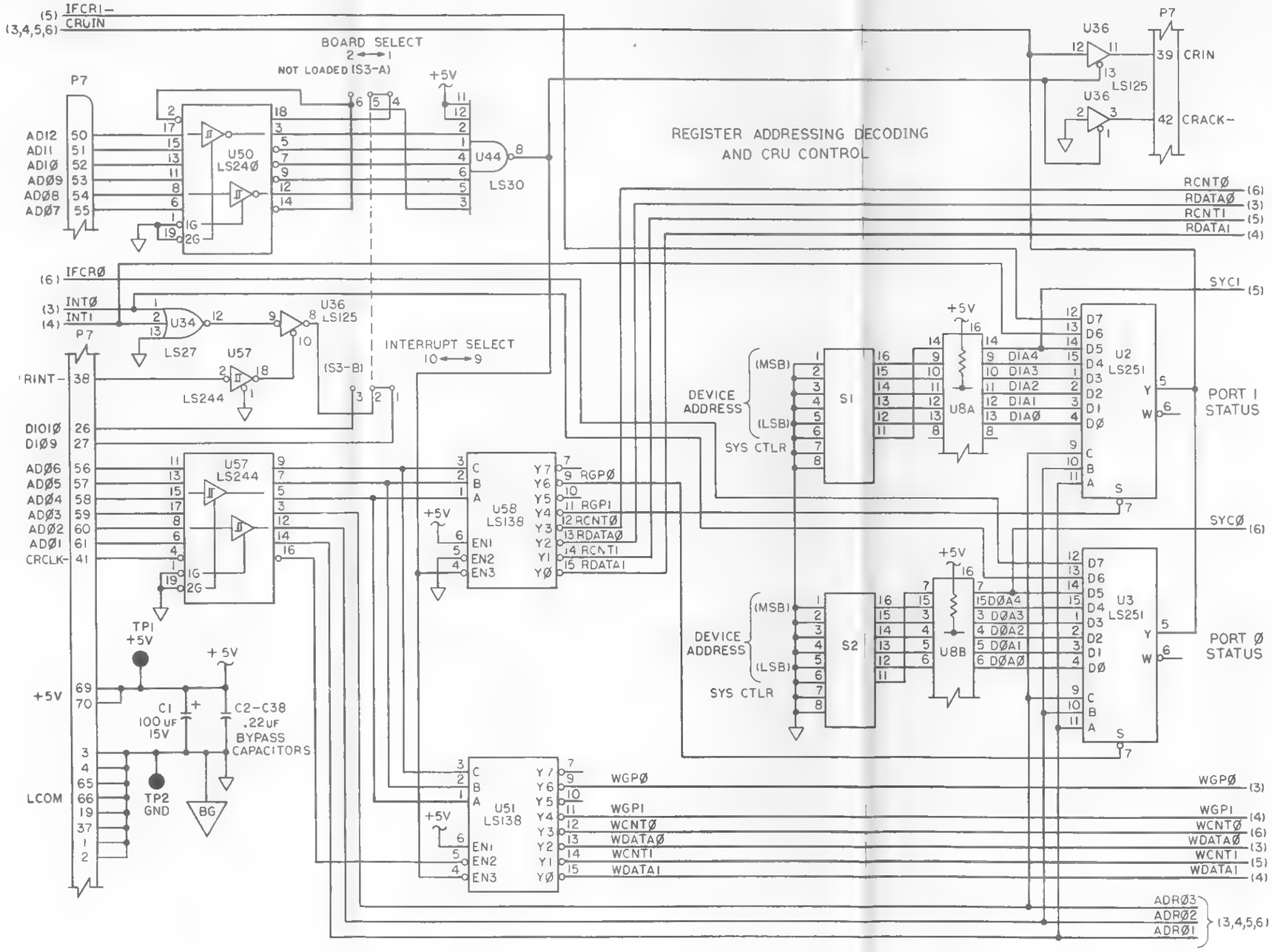

Figure 6-6. IEEE-488 Interface Module Assembly (cont.)

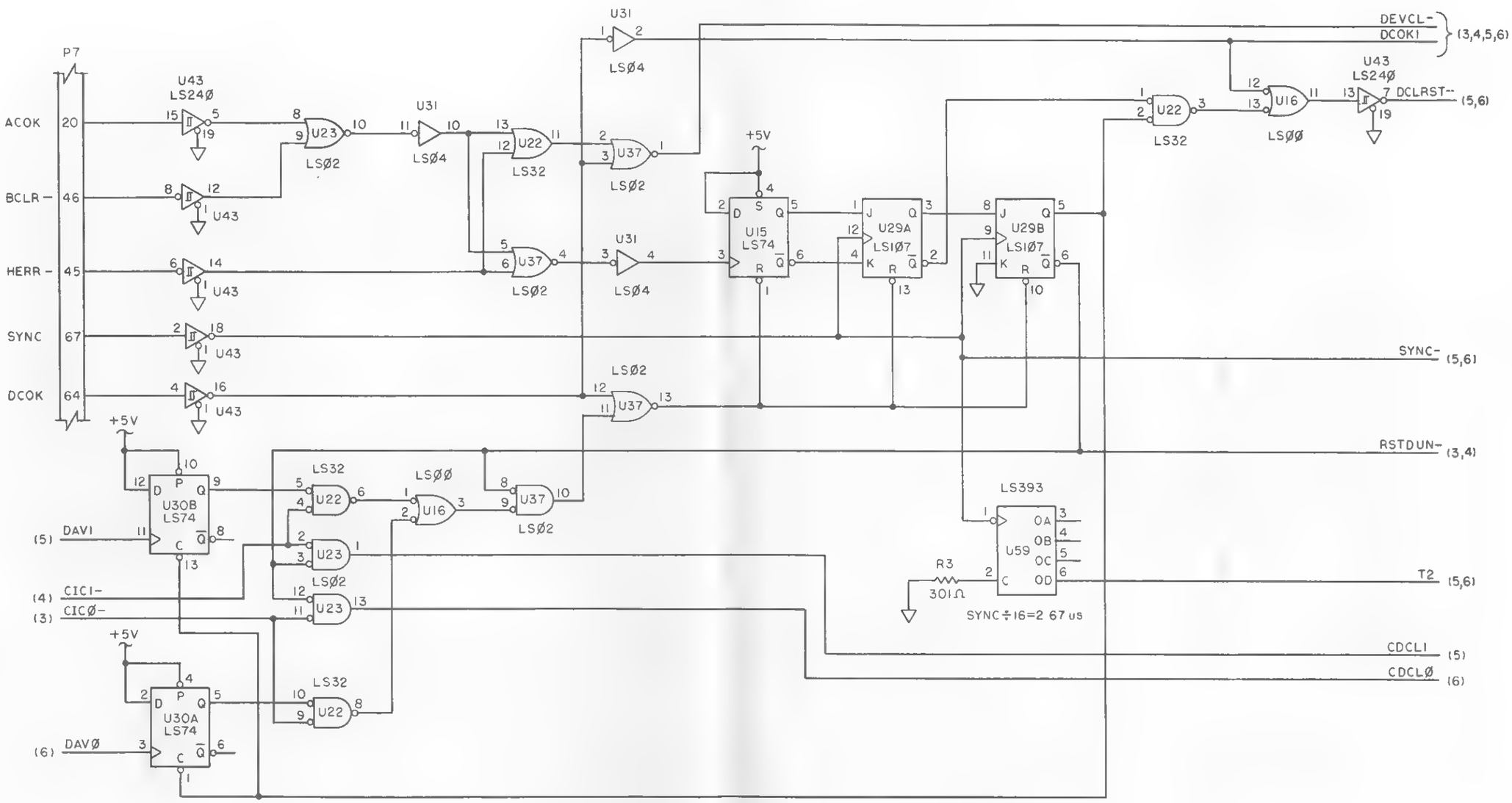

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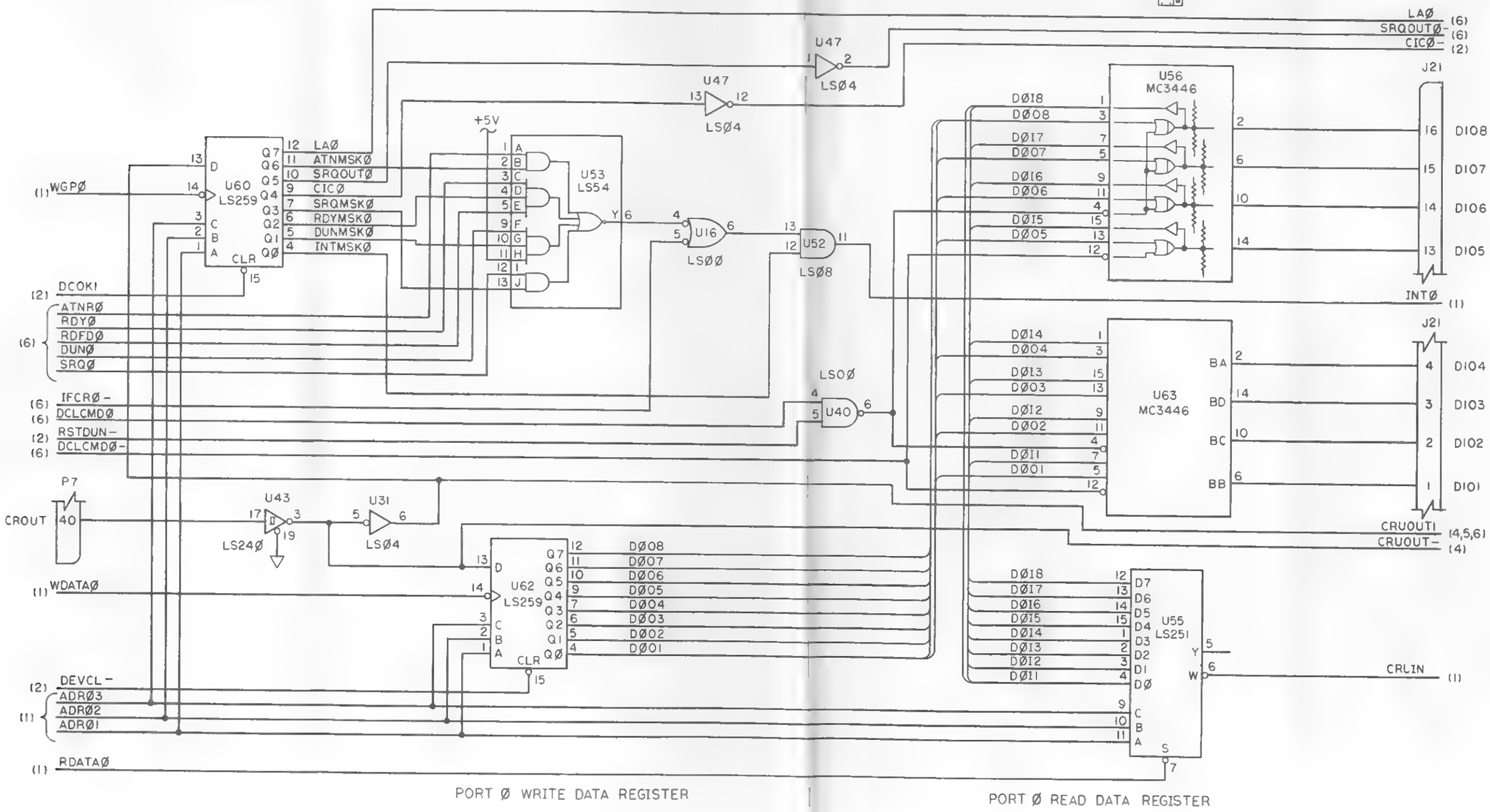
Figure 6-6. IEEE-488 Interface Module Assembly (cont.)

PORT Ø

PORT Ø INTERRUPT CONTROL

PORT Ø DATA DRIVERS



PORT Ø WRITE DATA REGISTER

PORT Ø READ DATA REGISTER

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Figure 6-6. IEEE-488 Interface Module Assembly (cont.)

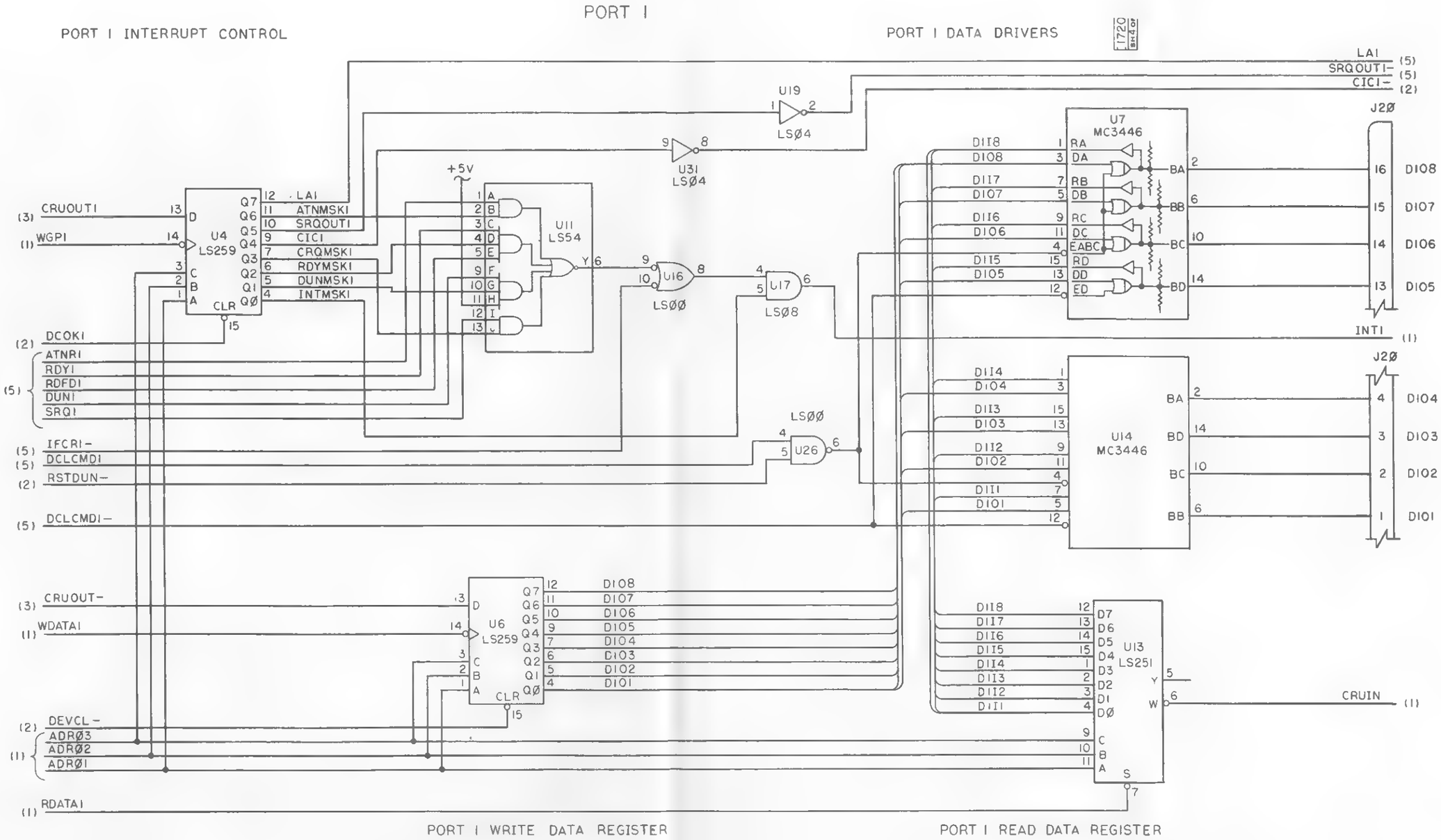

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Figure 6-6. IEEE-488 Interface Module Assembly (cont.)

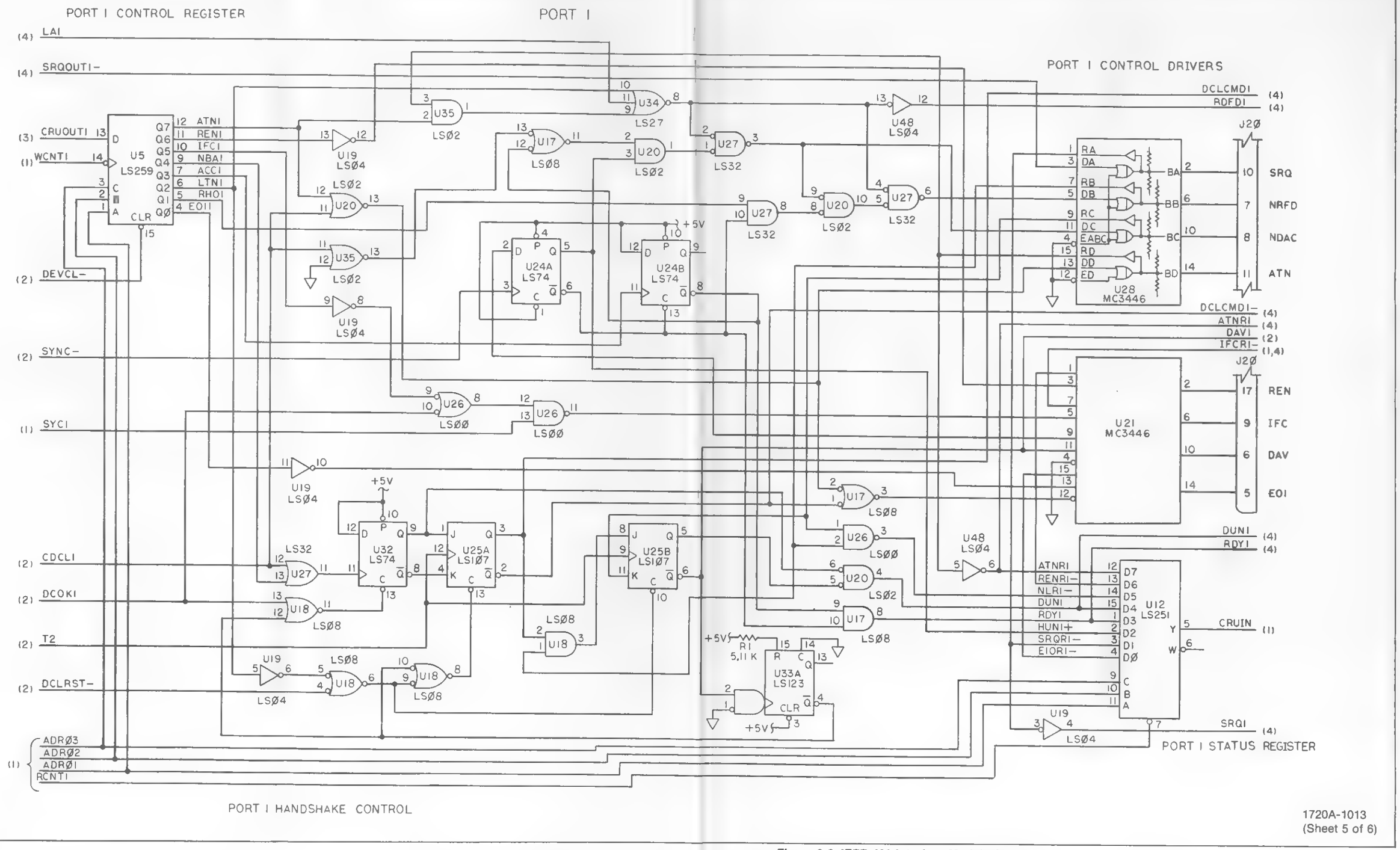

Figure 6-6. IEEE-488 Interface Module Assembly (cont.)

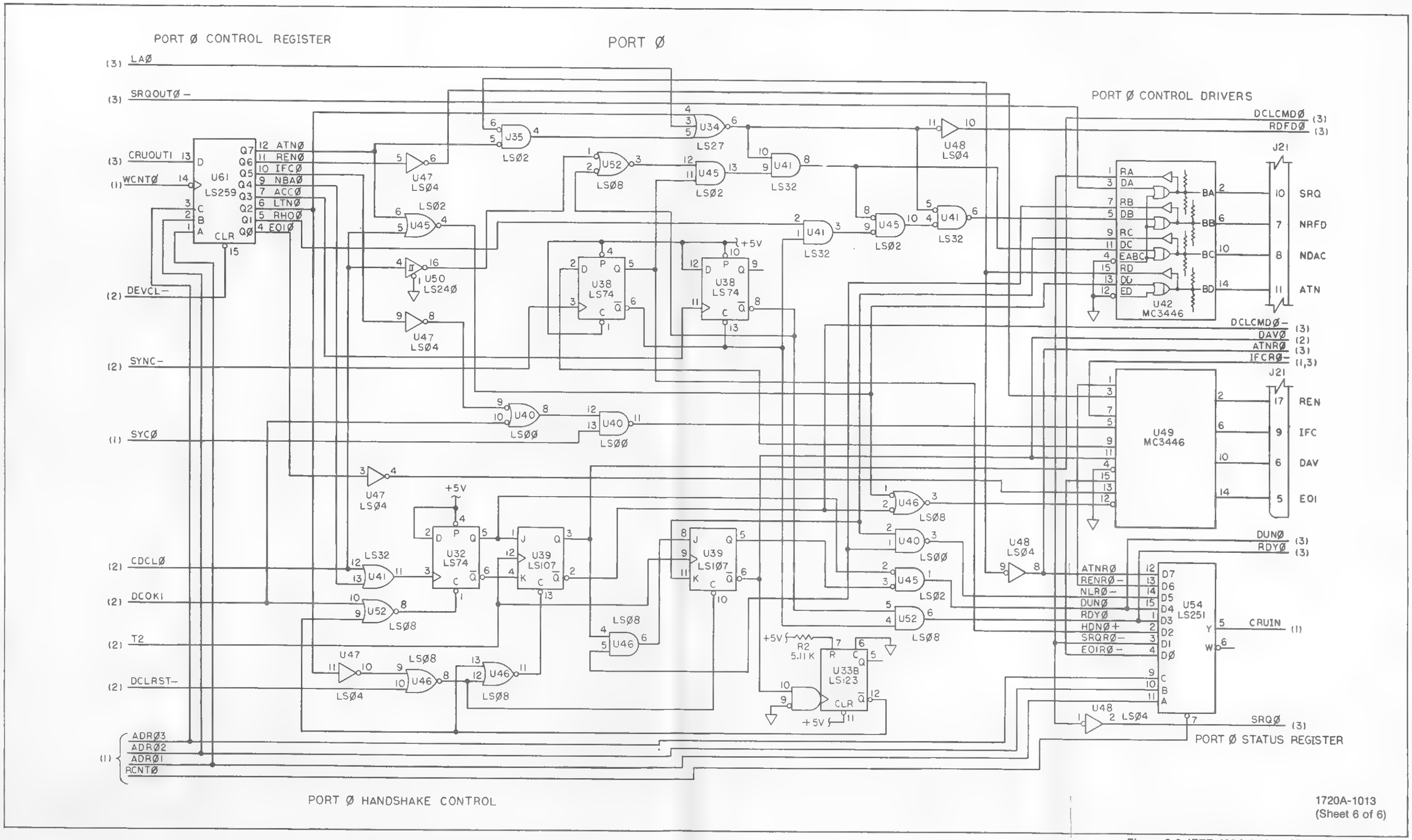

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Figure 6-6. IEEE-488 Interface Module Assembly (cont.)

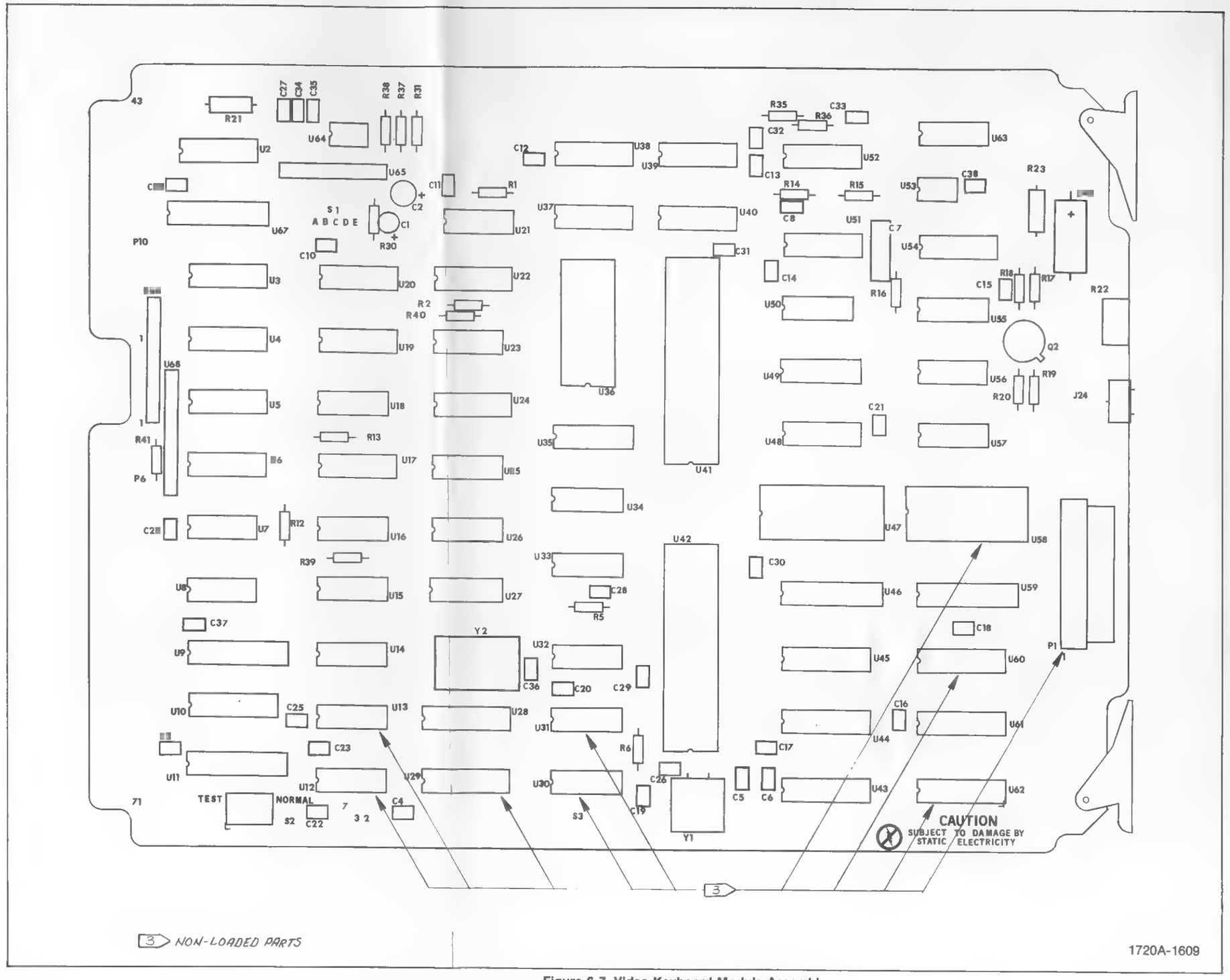
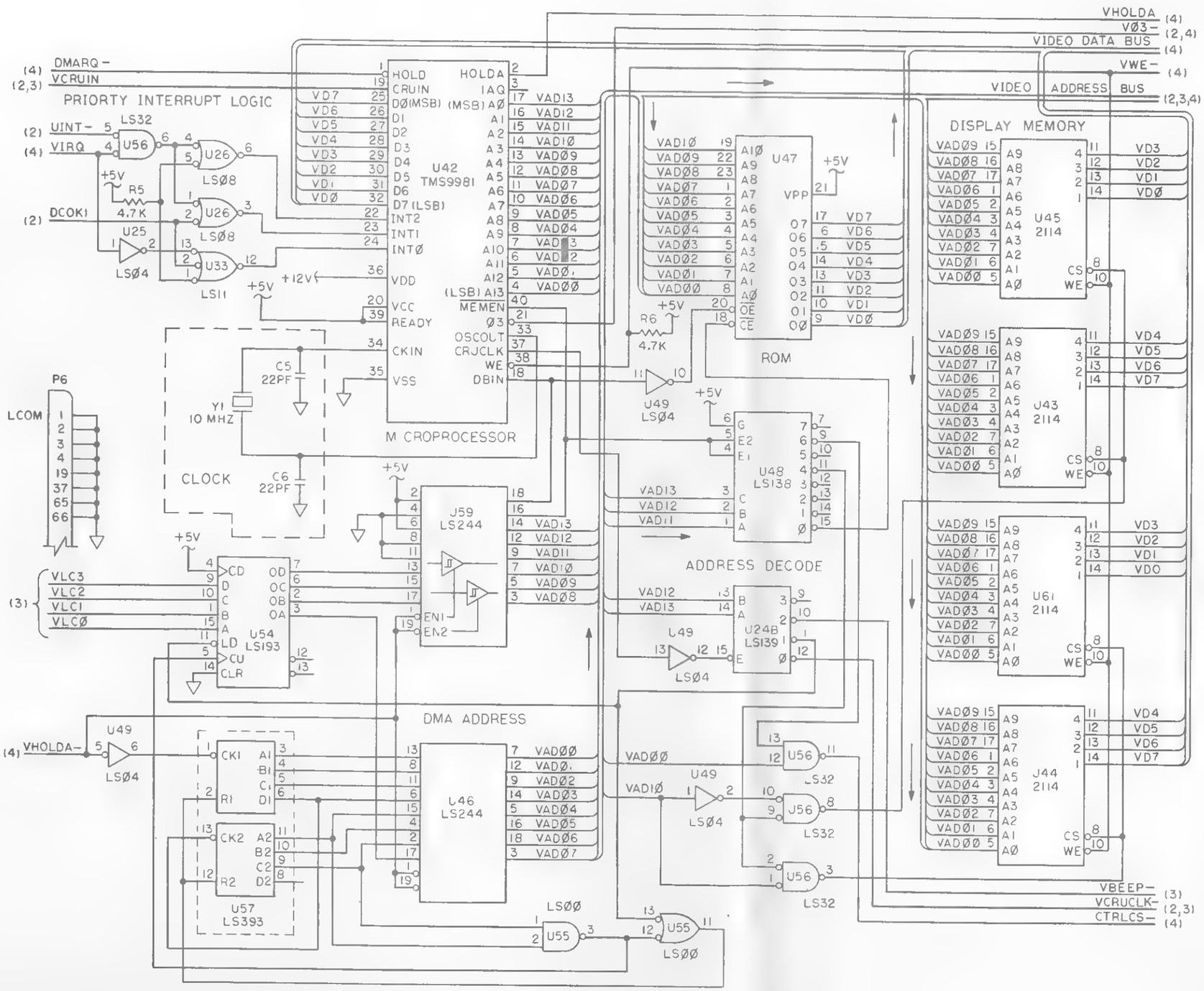


Figure 6-7. Video Keyboard Module Assembly



NOTES—UNLESS OTHERWISE SPECIFIED:

1. VADØØ LABELED AS AI3 ON 9981 (MPU-U42) IS ALSO CRUOUT ON THE CRU BUS. SEE U28–8, U2–13, U4–13, U17–13.

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Figure 6-7. Video Keyboard Module Assembly (cont)

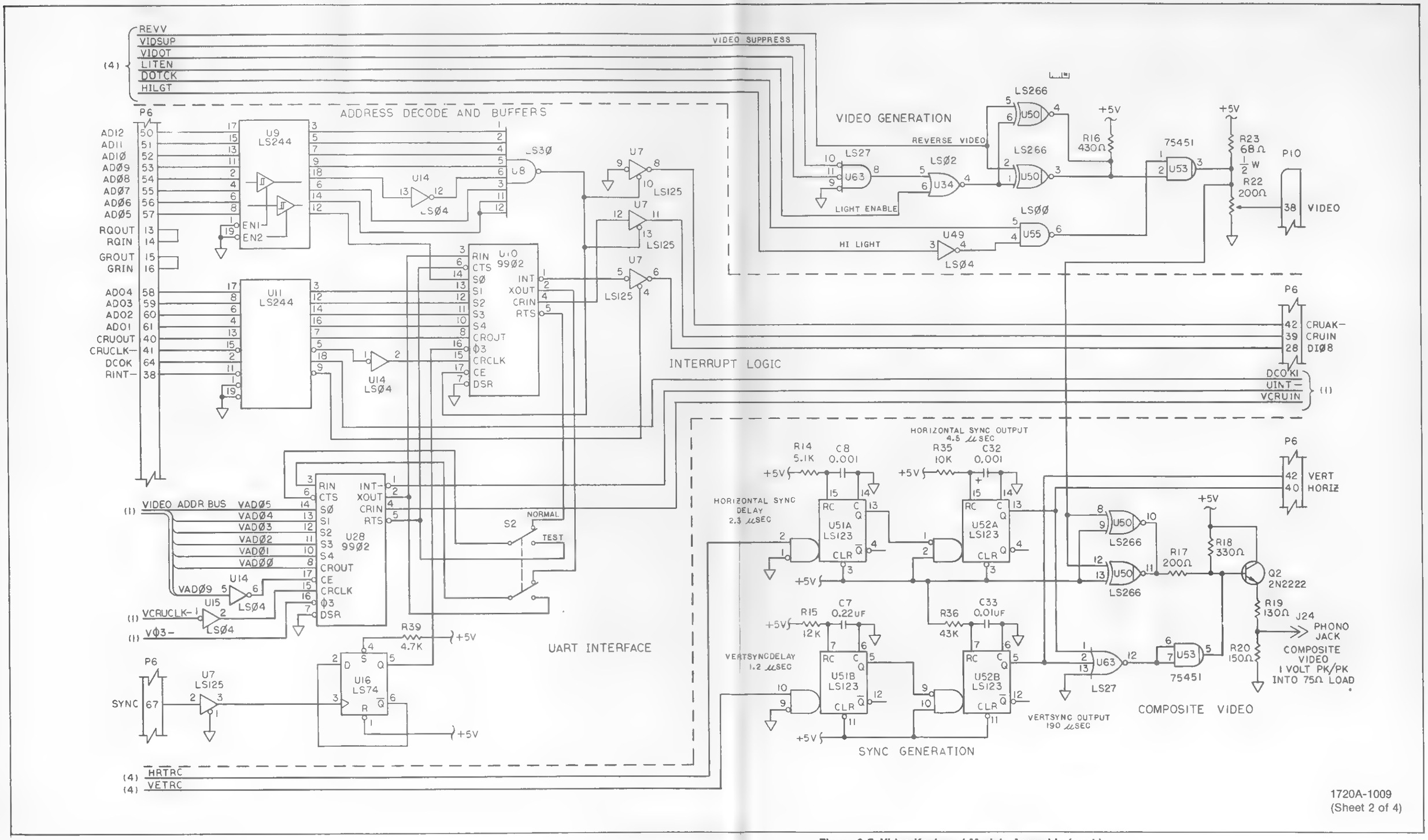

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Figure 6-7. Video Keyboard Module Assembly (cont.)

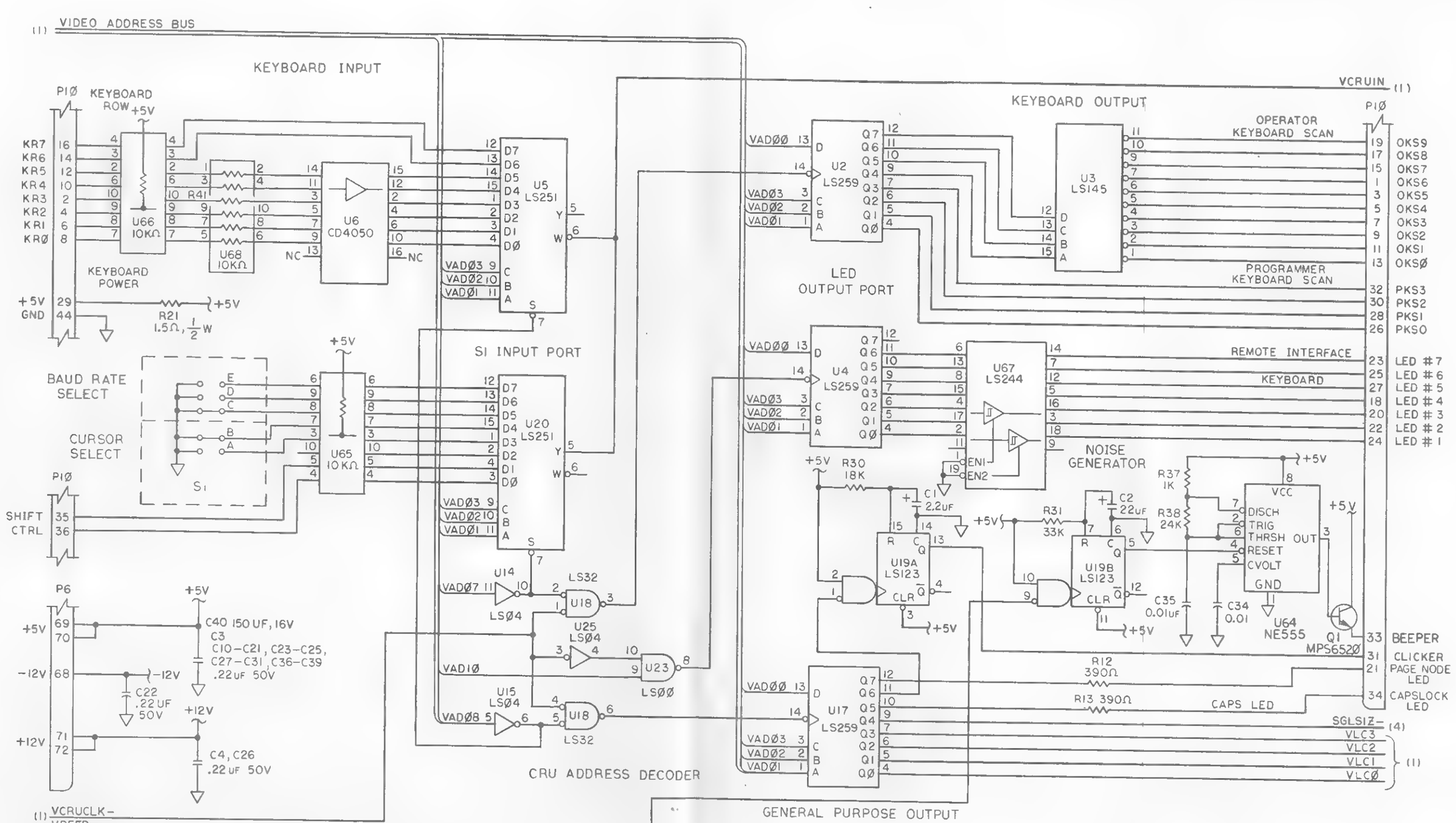

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Figure 6-7. Video Keyboard Module Assembly (cont.)

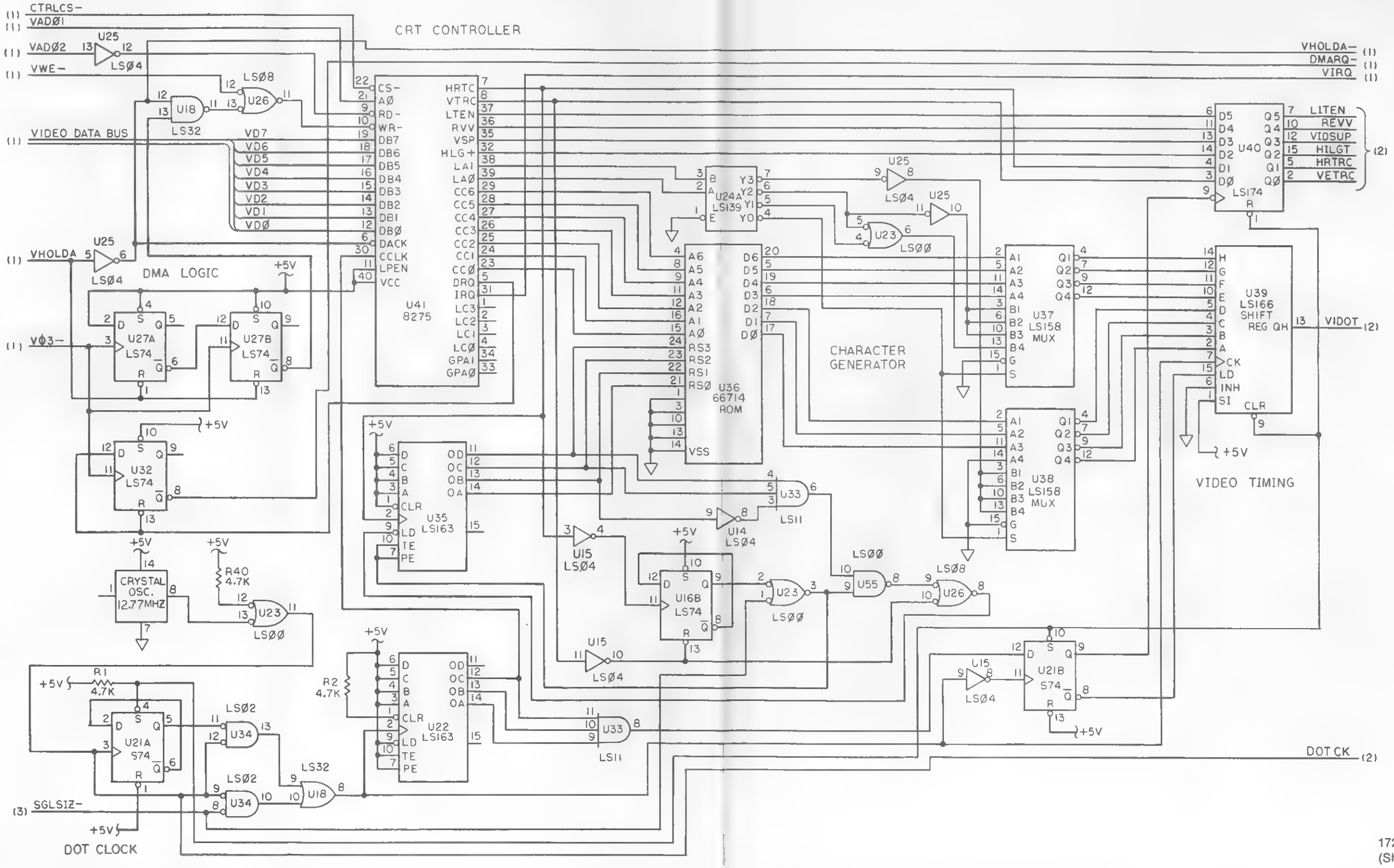

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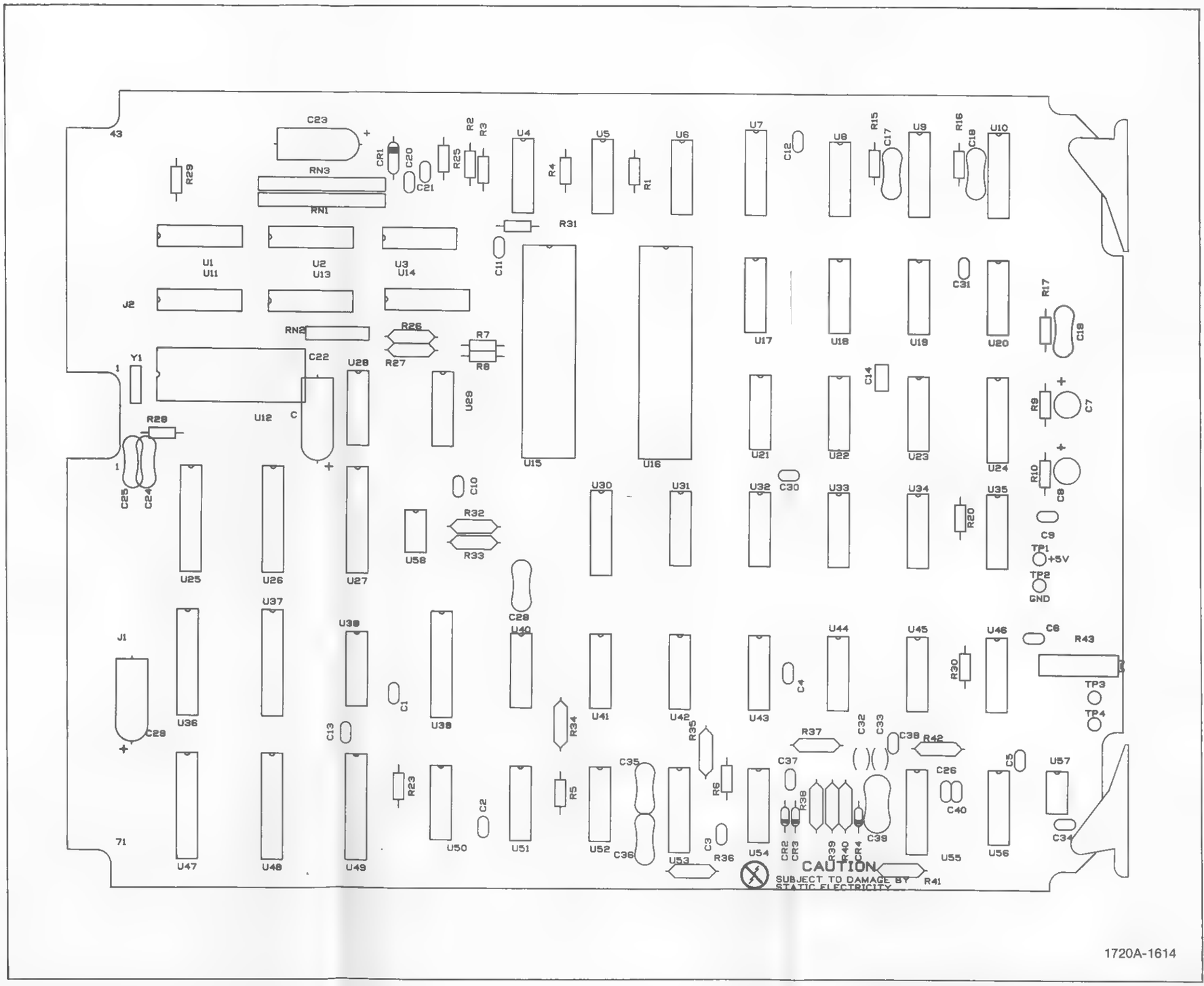
Figure 6-7. Video Keyboard Module Assembly (cont.)



1720A-1614

Figure 6-8. DMA Floppy/Clock Module Assembly

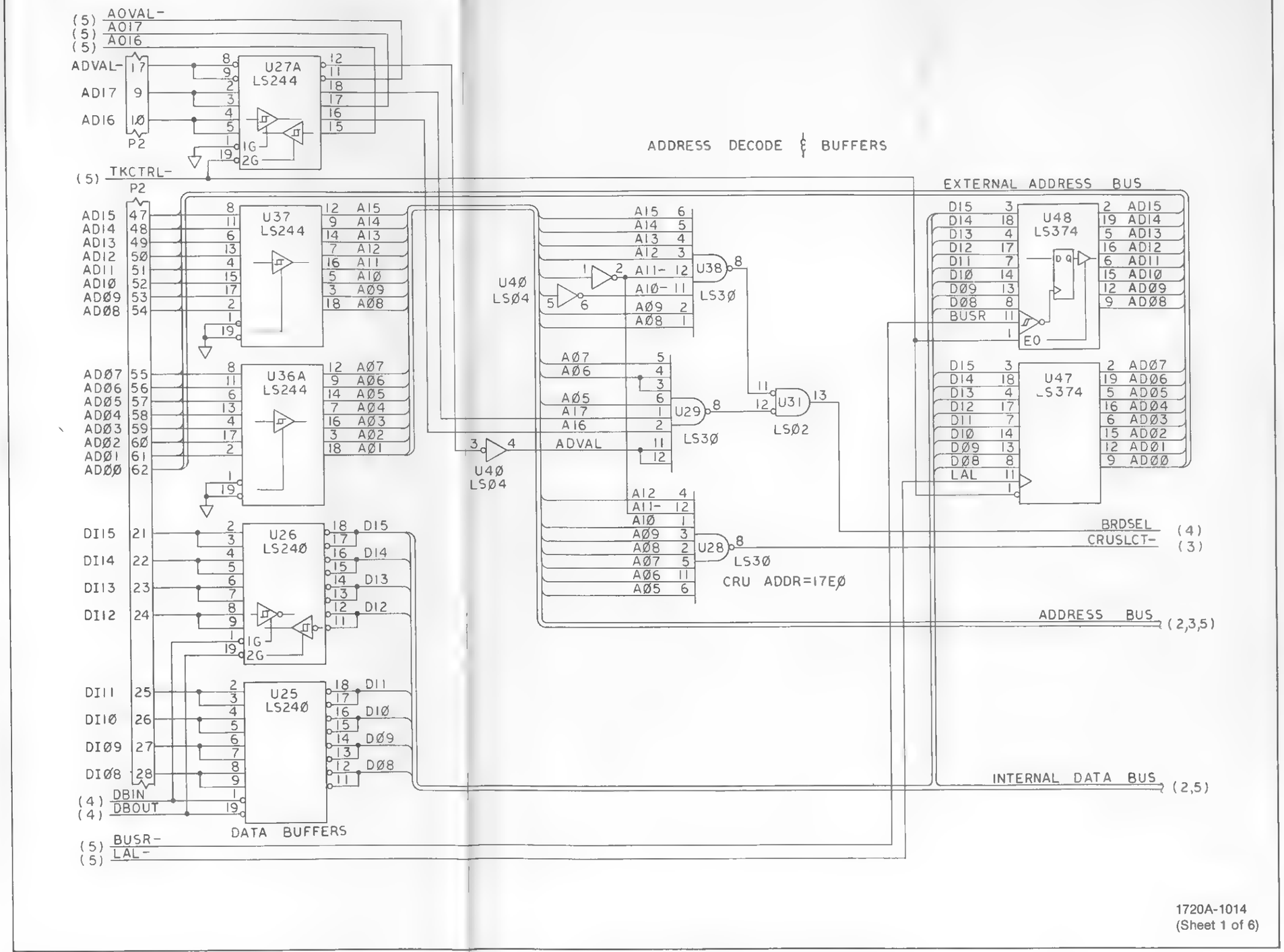


Figure 6-8. DMA Floppy/Clock Module Assembly (cont.)

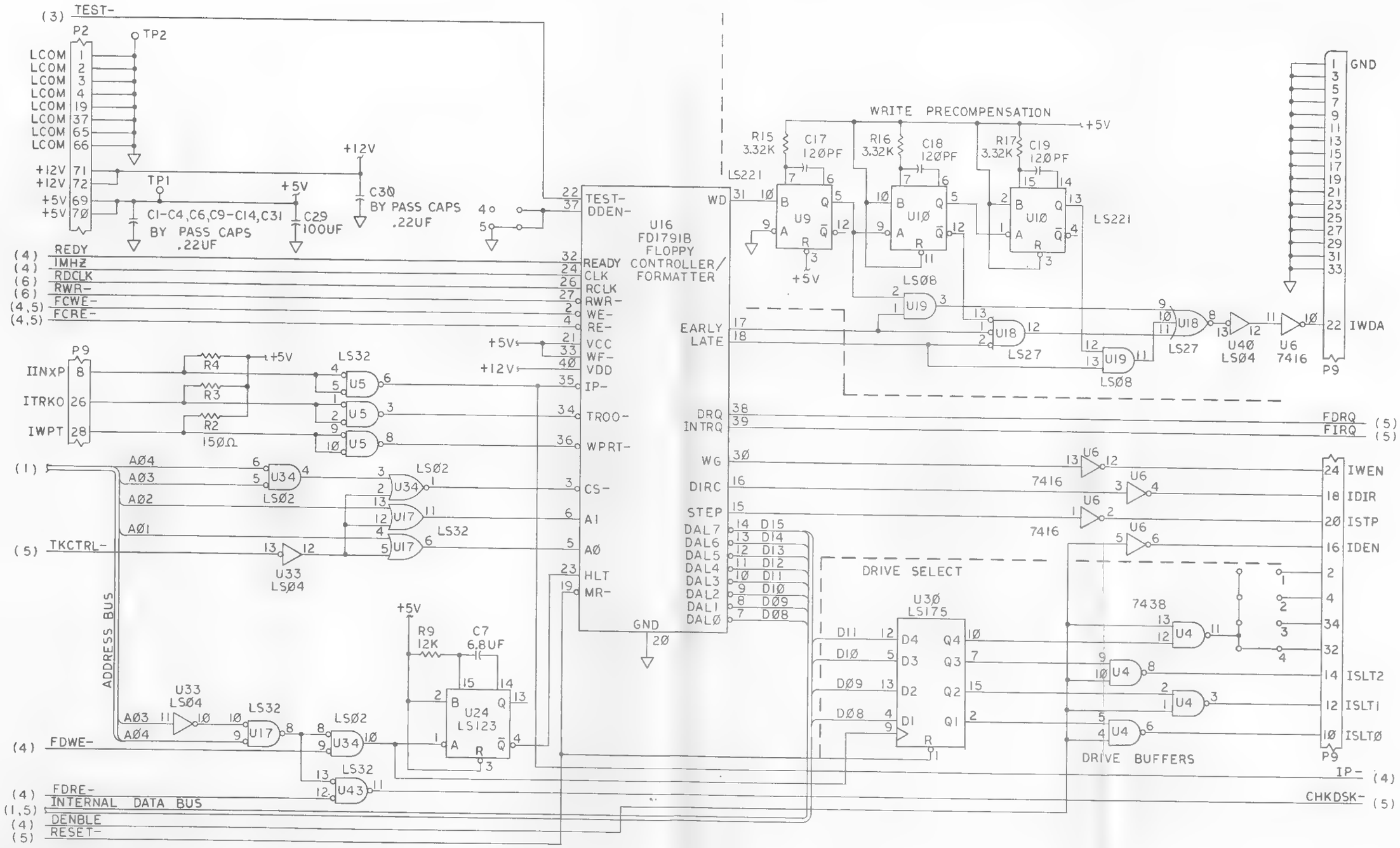


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Figure 6-8. DMA Floppy/Clock Module Assembly (cont.)

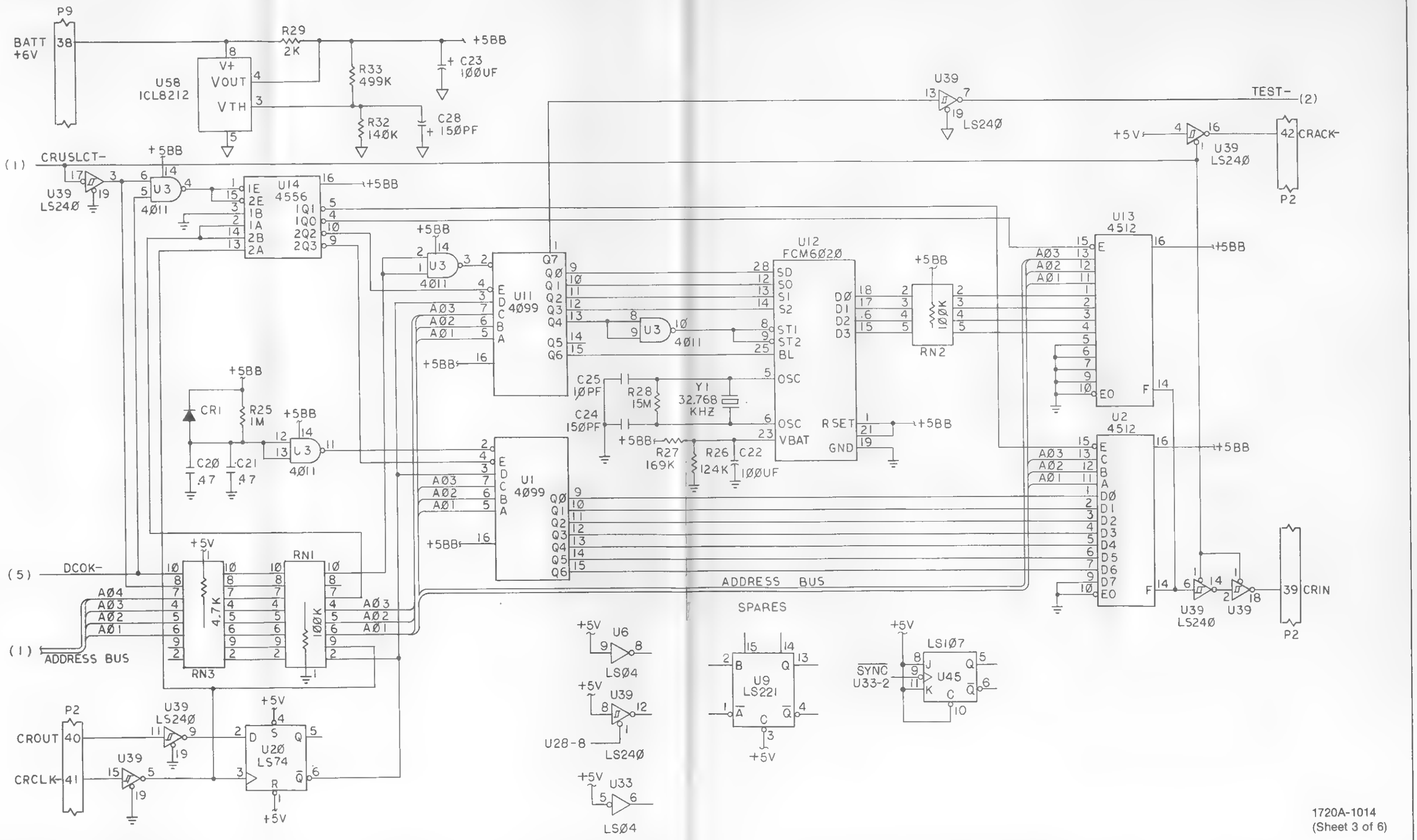

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Figure 6-8. DMA Floppy/Clock Module Assembly (cont.)

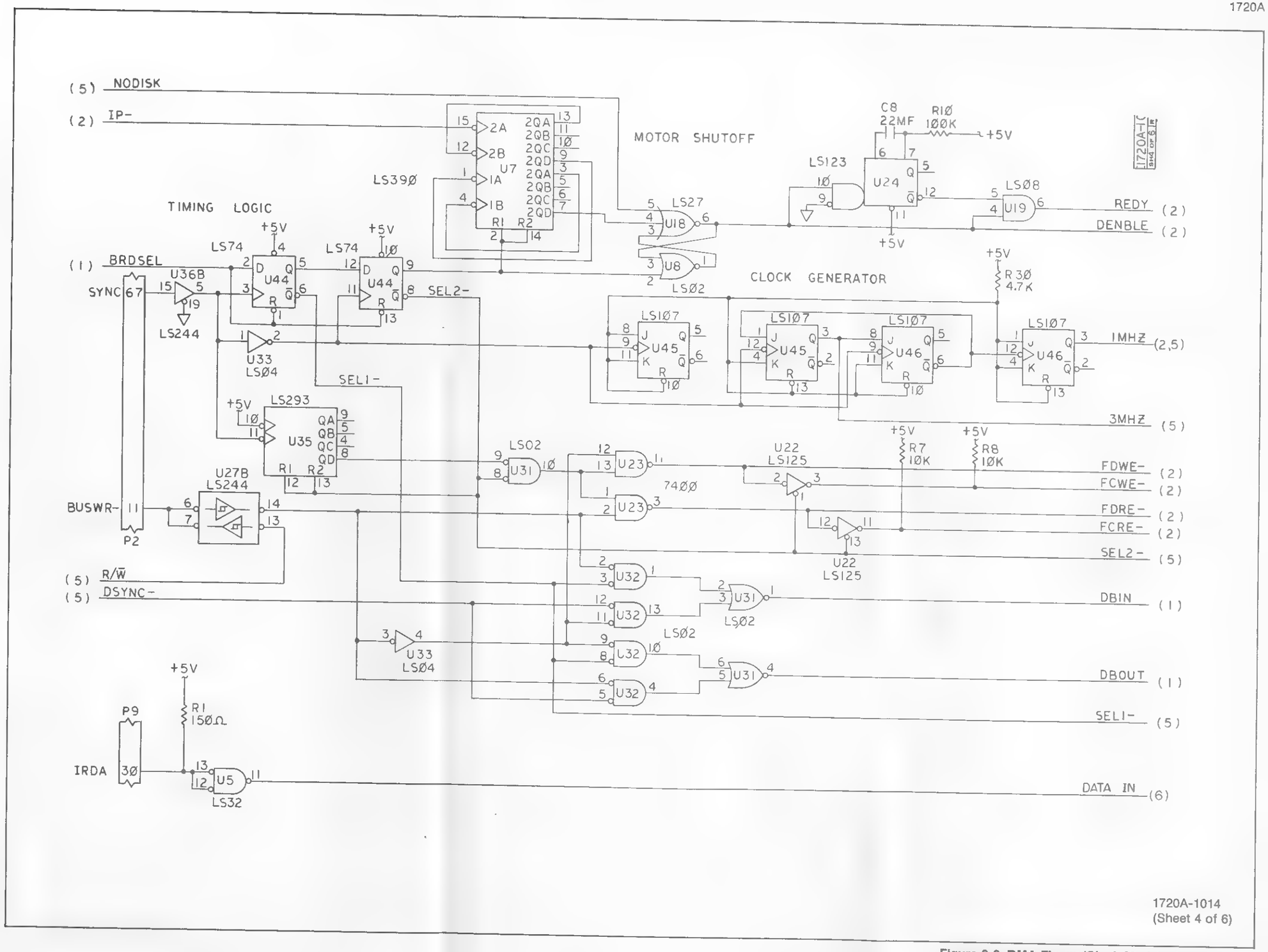

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Figure 6-8. DMA Floppy/Clock Module Assembly (cont.)

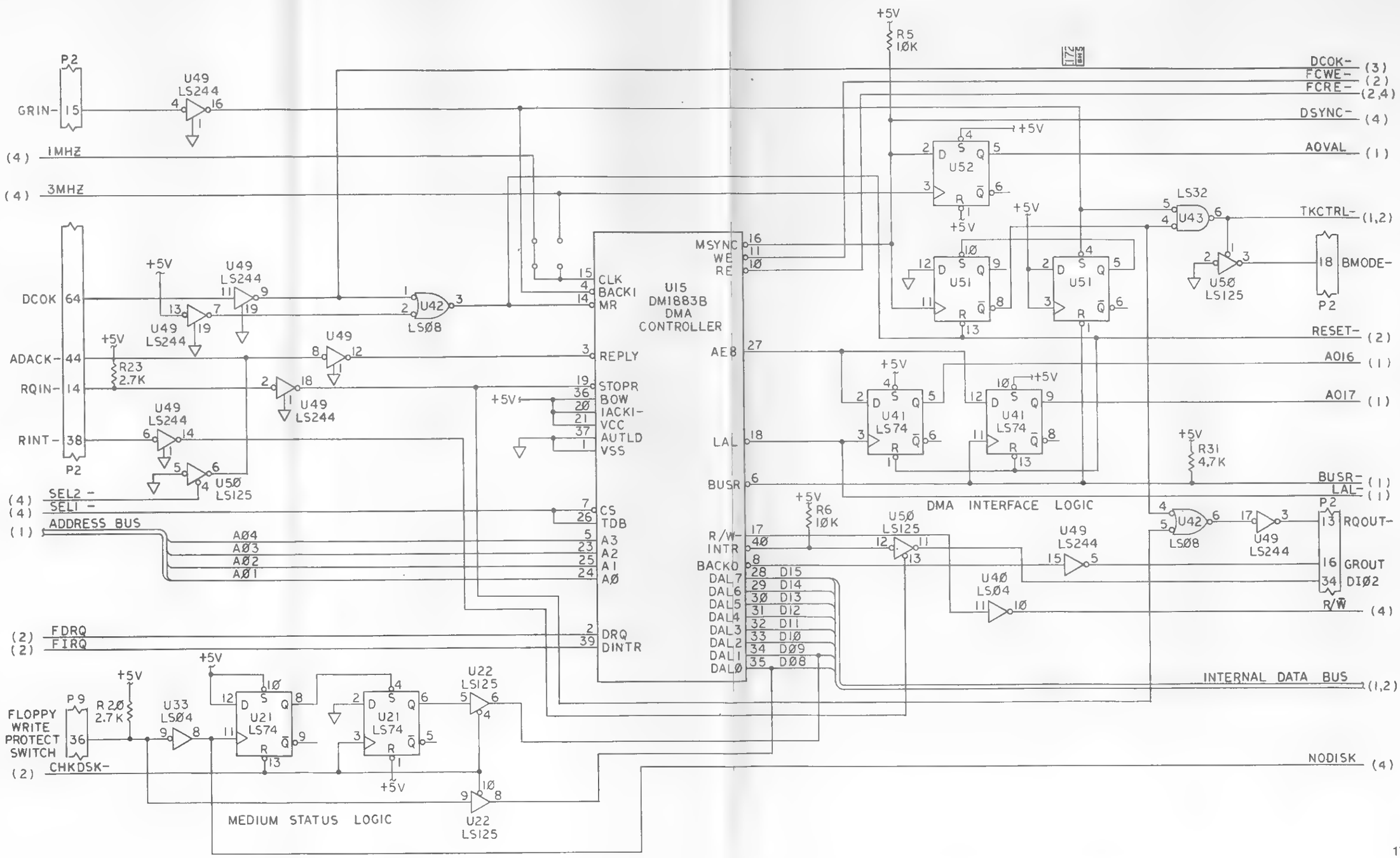

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Figure 6-8. DMA Floppy/Clock Module Assembly (cont.)

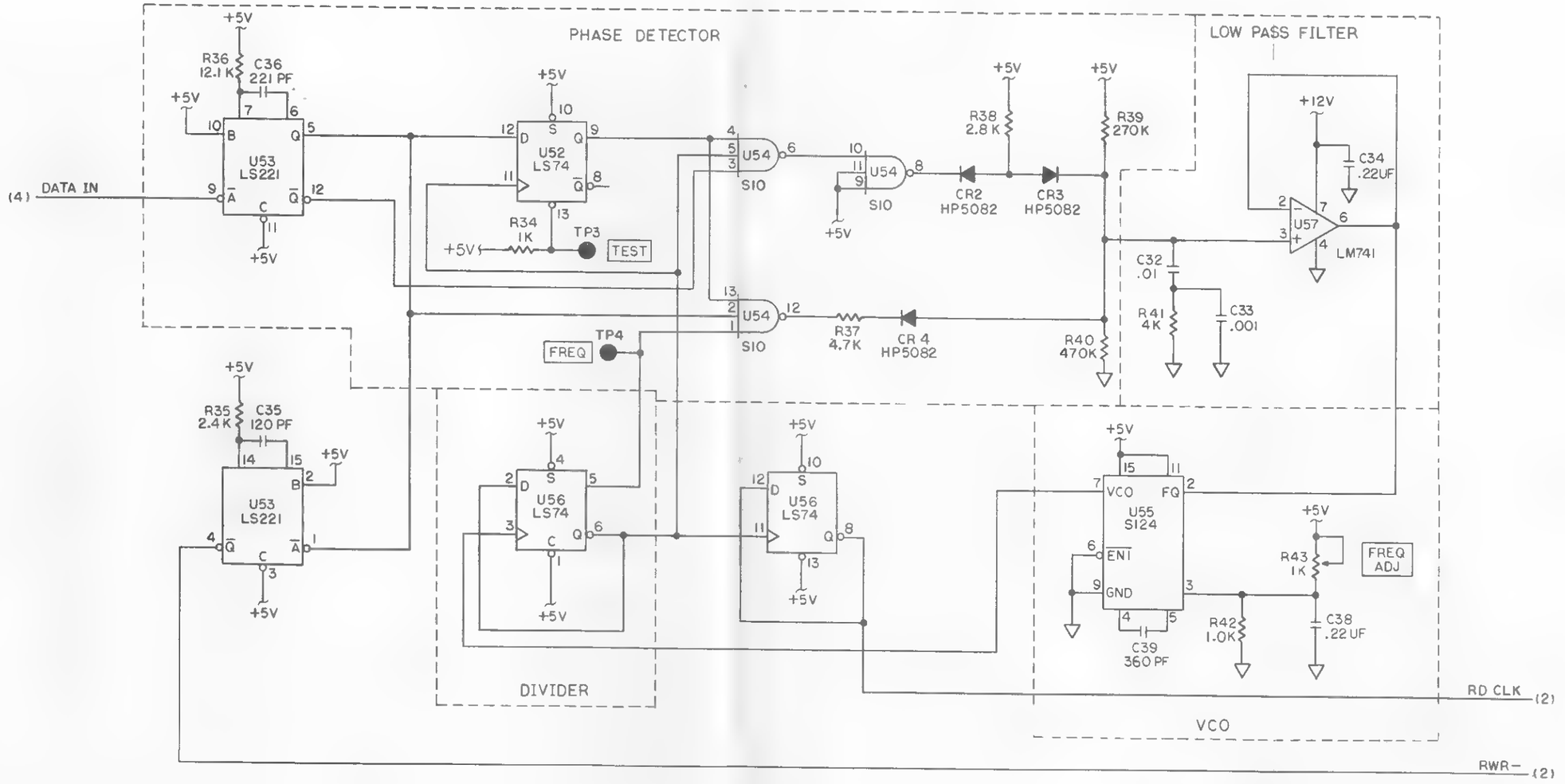

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Figure 6-8. DMA Floppy/Clock Module Assembly (cont.)

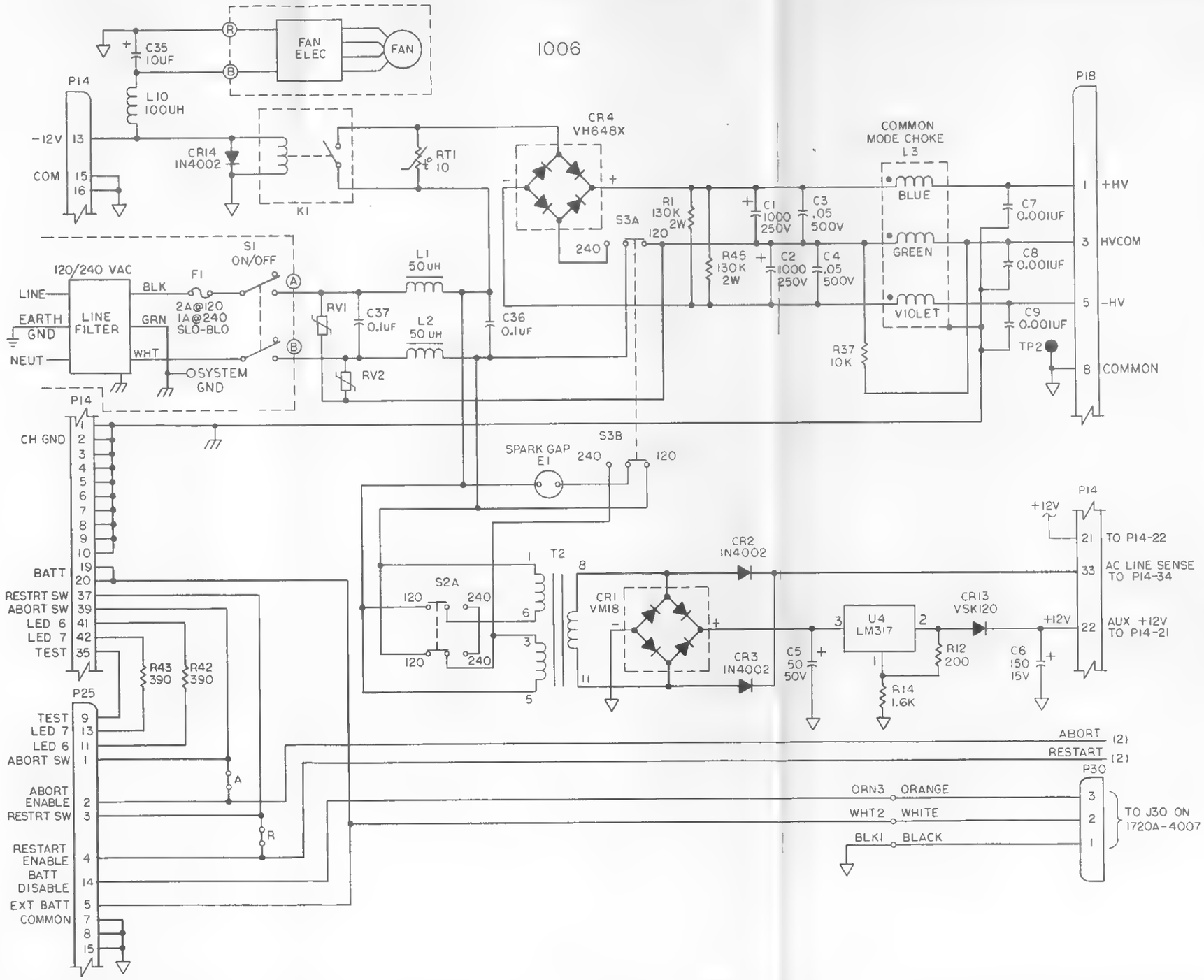

Figure 6-9. Power Supply Module Assembly

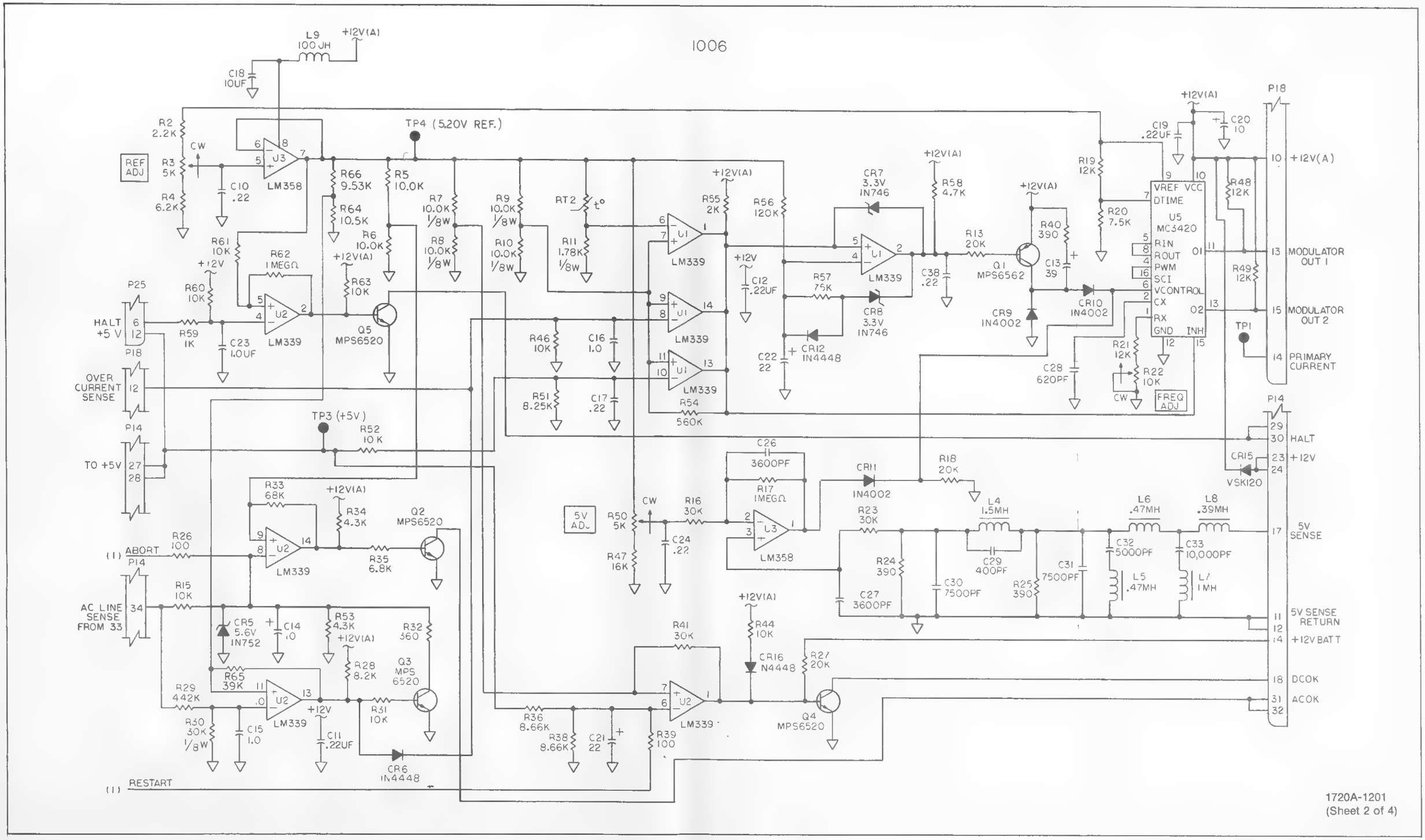

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Figure 6-9. Power Supply Module Assembly (cont.)

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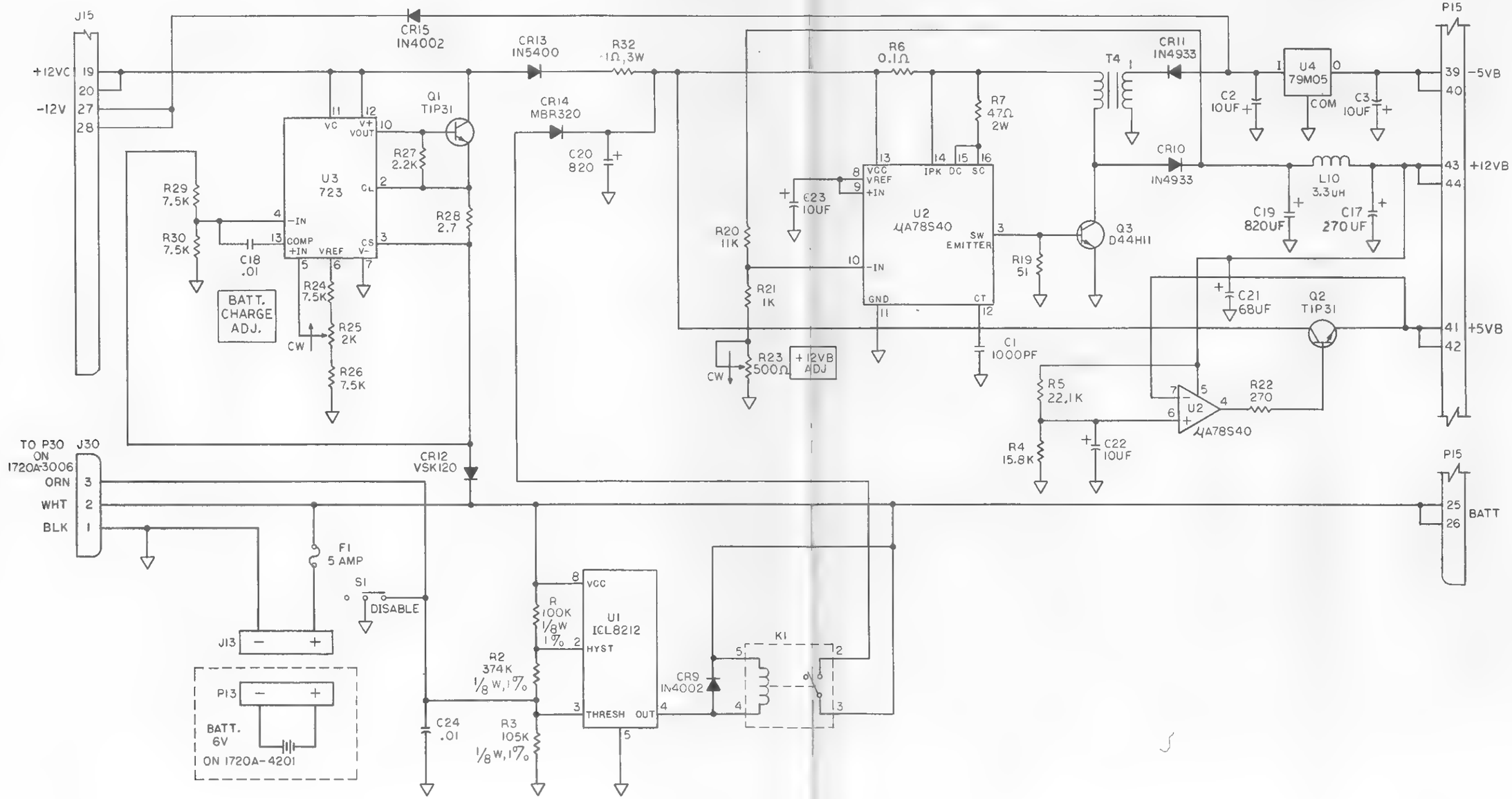

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Figure 6-9. Power Supply Module Assembly (cont.)

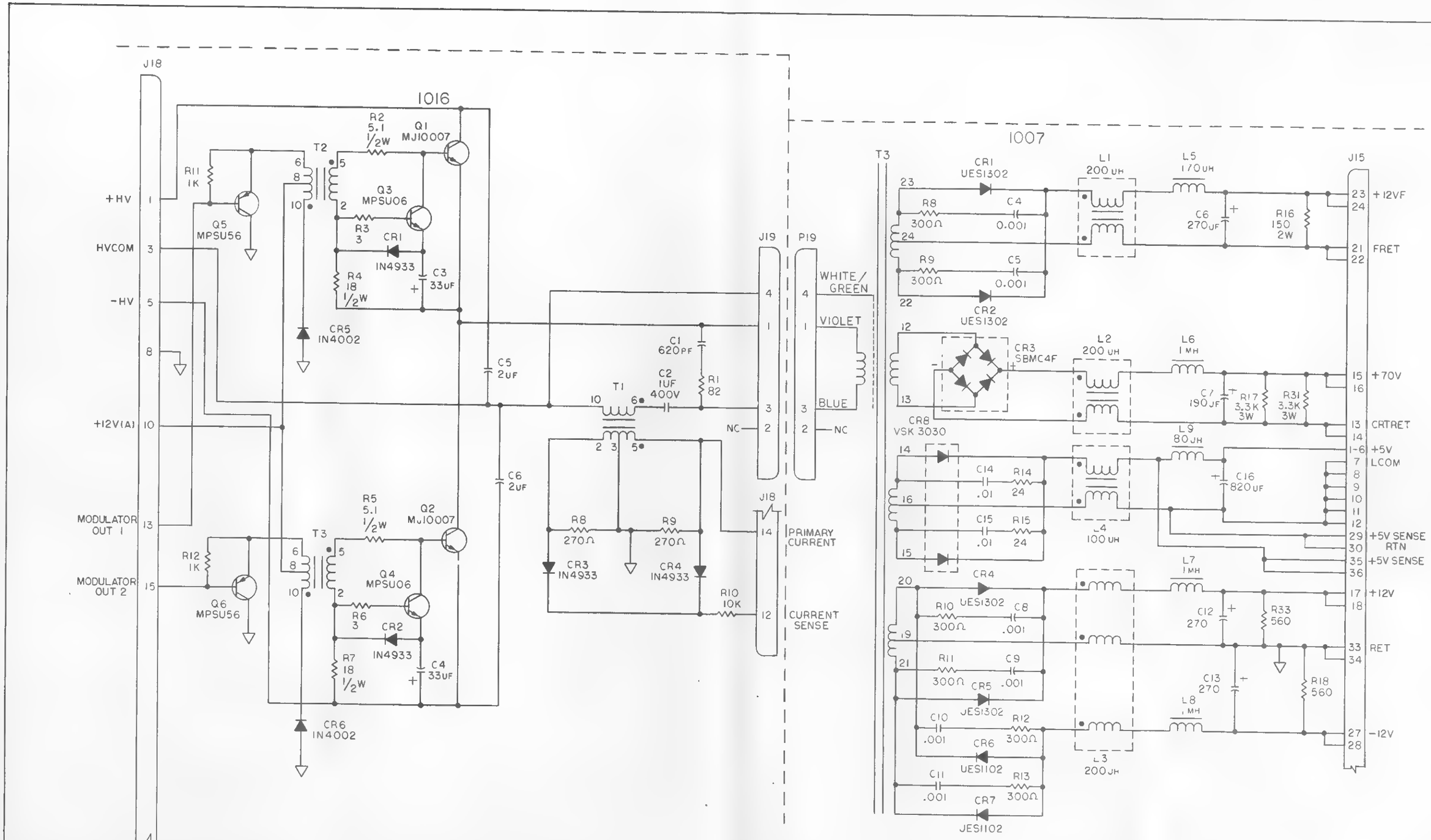

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Figure 6-9. Power Supply Module Assembly (cont.)

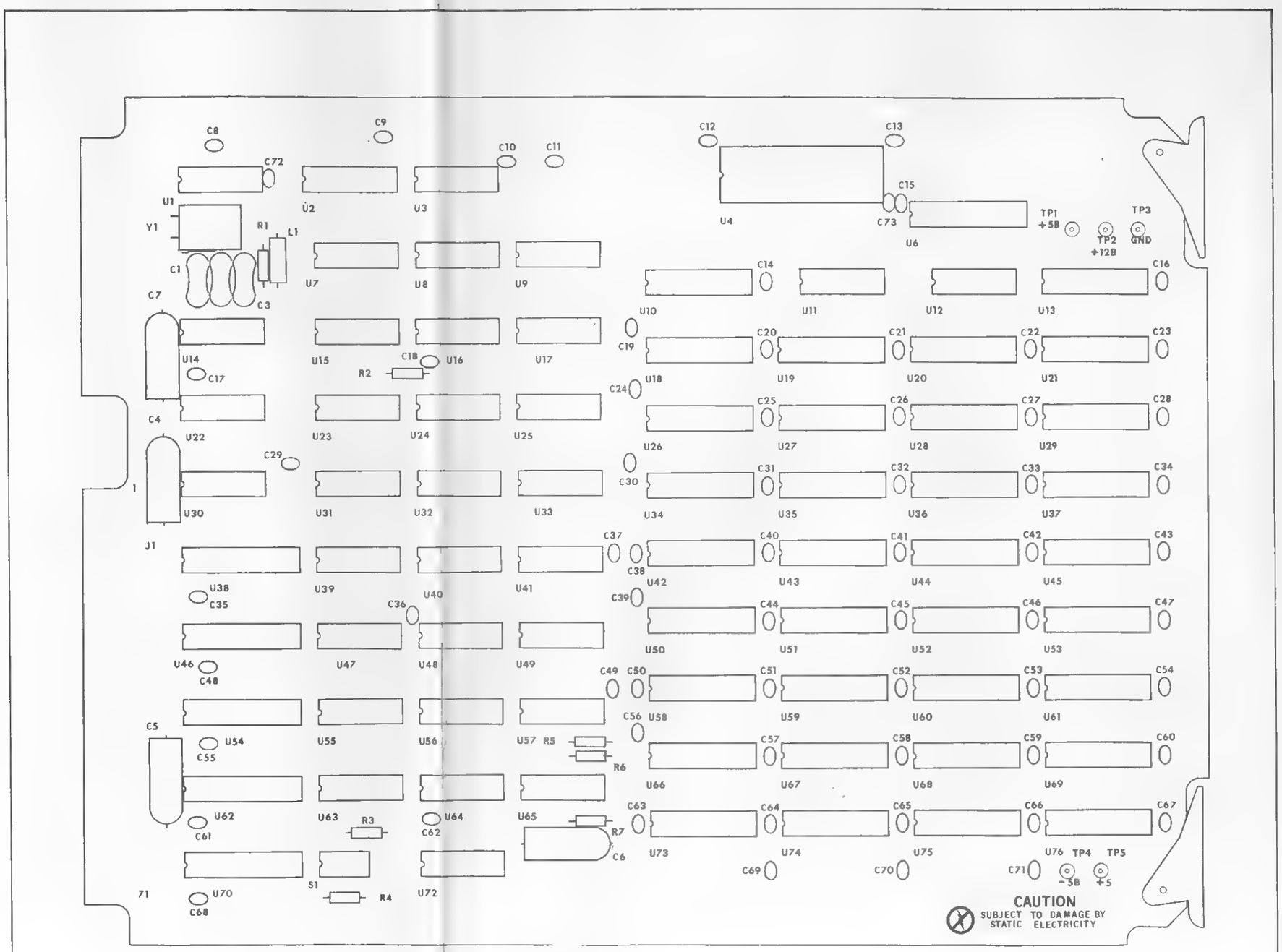

Figure 6-10. Electronic Disk Module Assembly

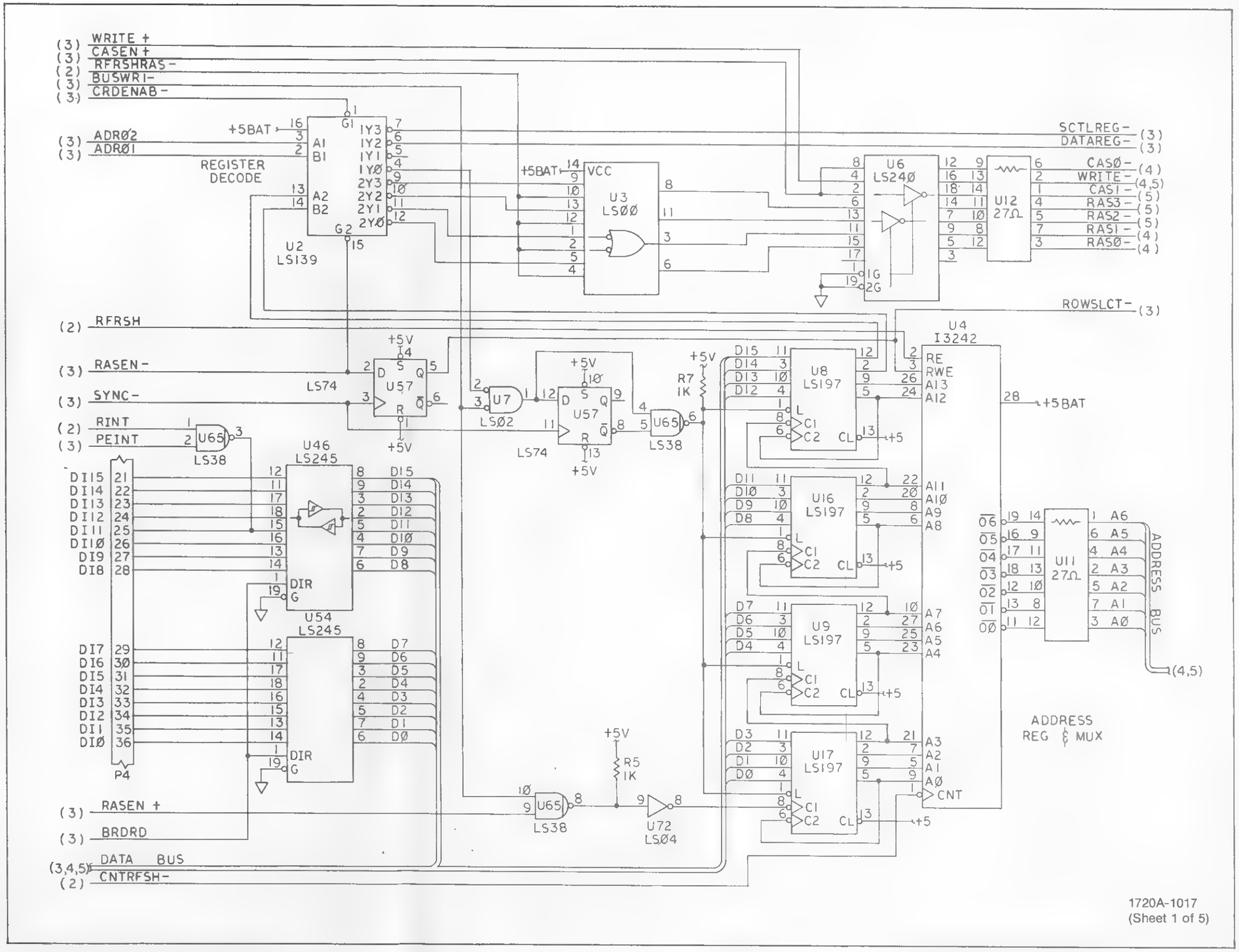

Figure 6-10. Electronic Disk Module Assembly (cont.)

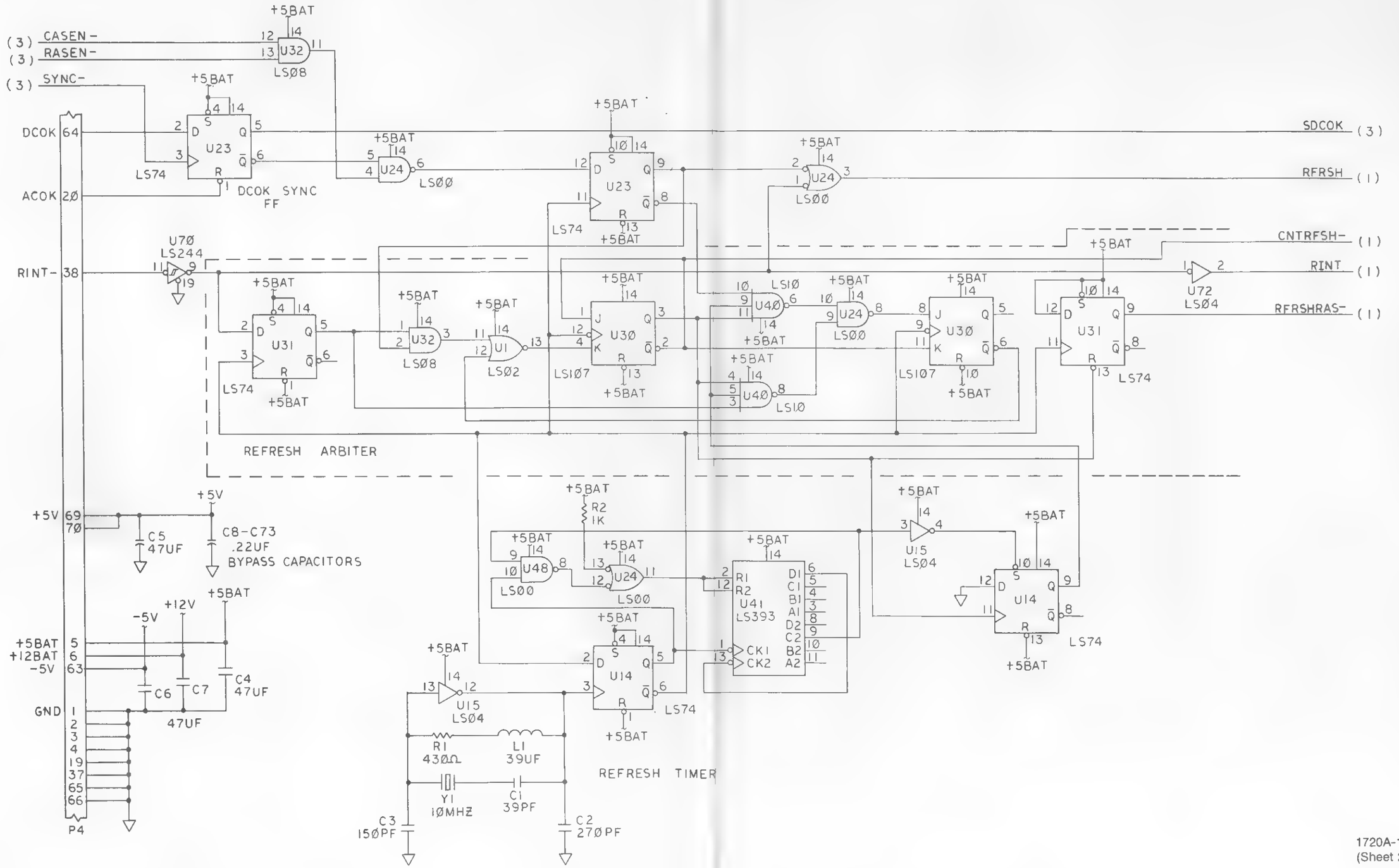

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Figure 6-10. Electronic Disk Module Assembly (cont.)

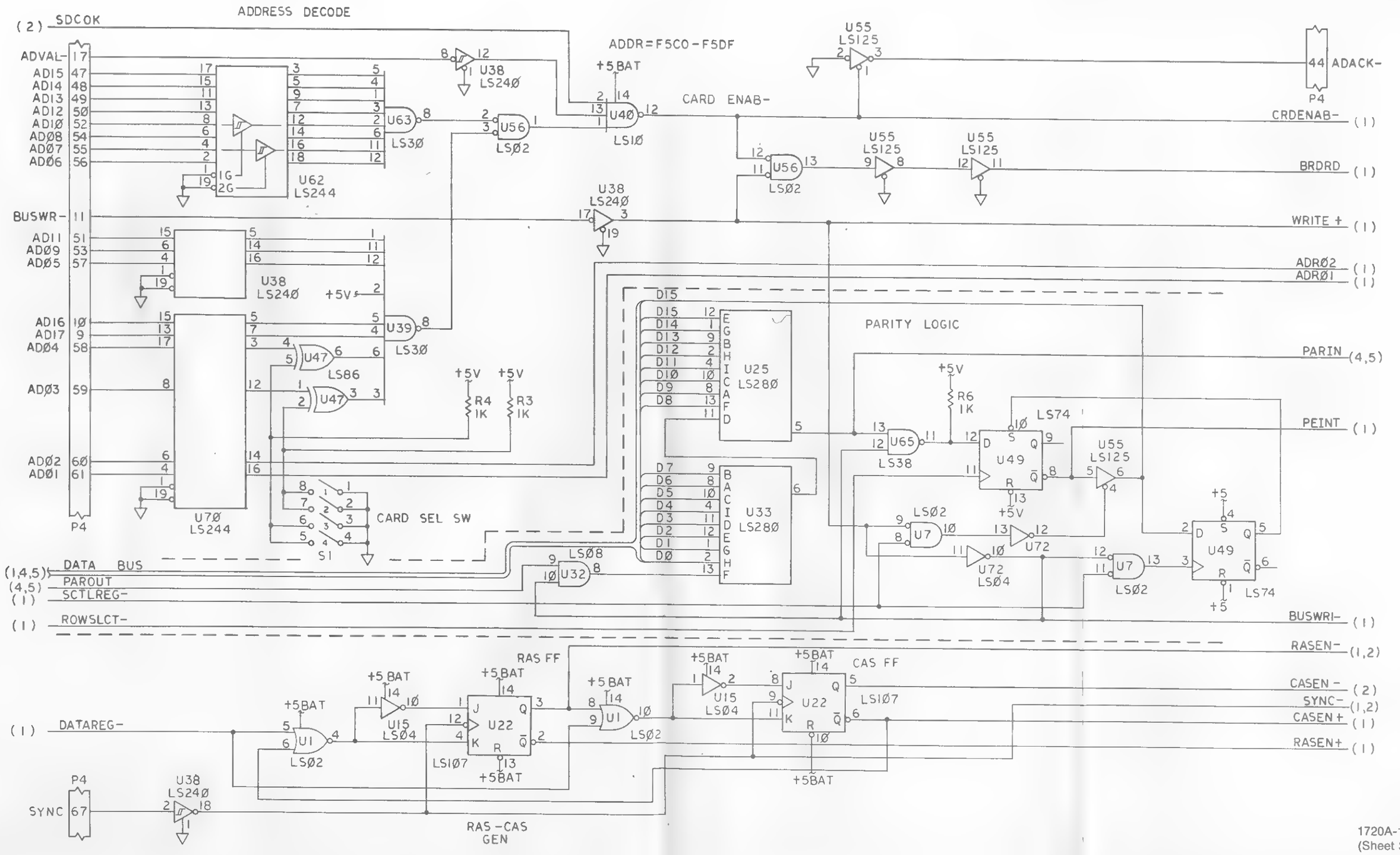

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Figure 6-10. Electronic Disk Module Assembly (cont.)

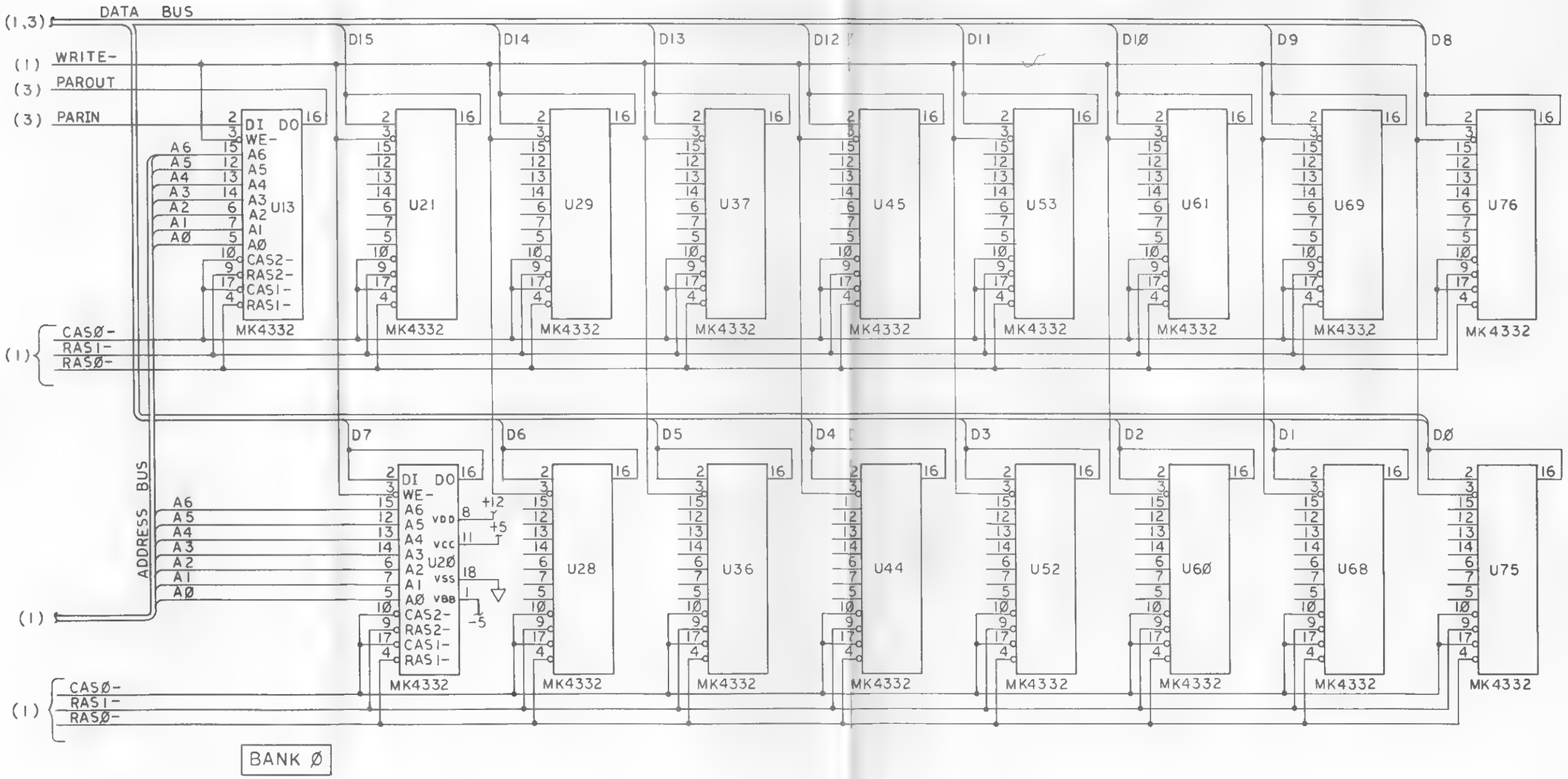

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Figure 6-10. Electronic Disk Module Assembly (cont.)

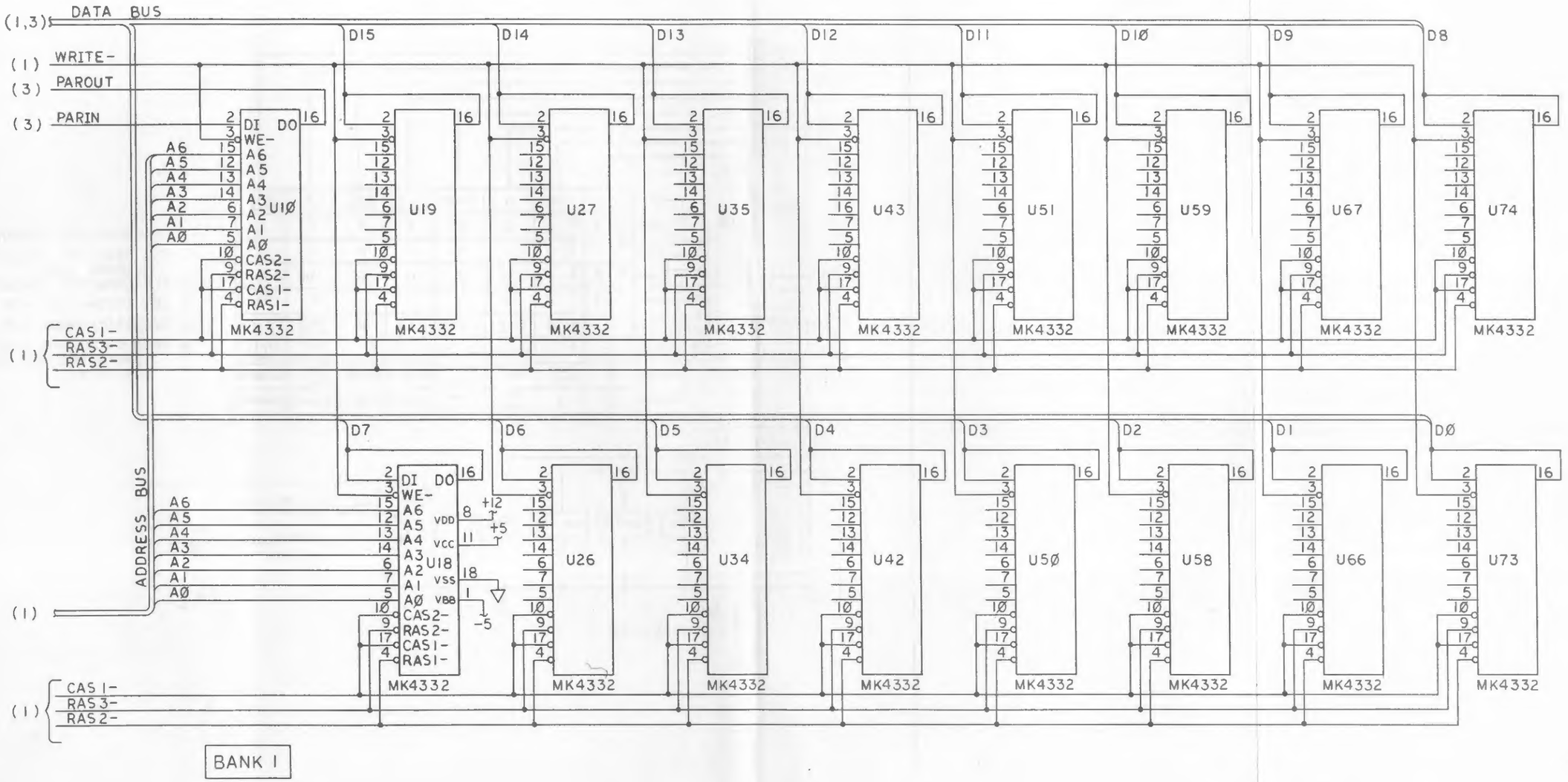

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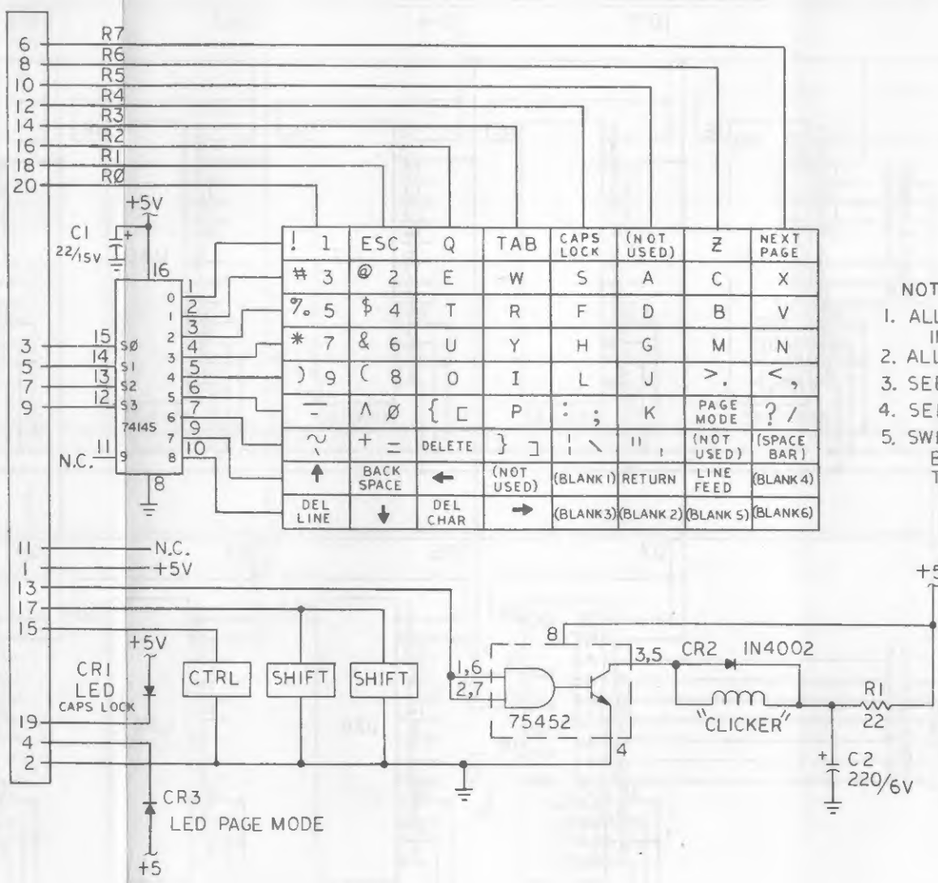
Figure 6-10. Electronic Disk Module Assembly (cont.)

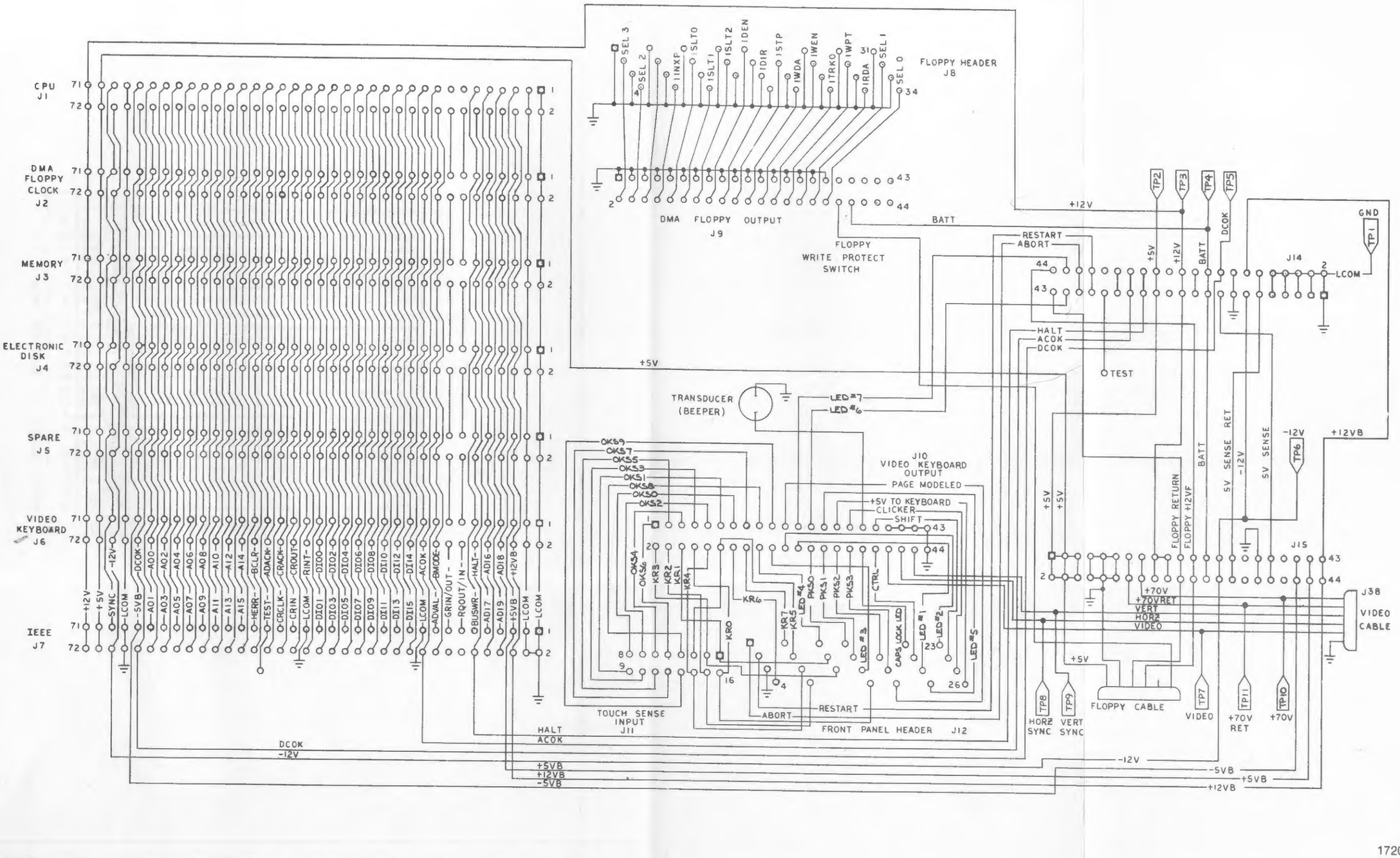


NOTES-UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTOR VALUES ARE GIVEN IN OHMS 1/4W.
2. ALL CAPACITOR VALUES ARE IN μF.
3. SEE 1720A-3010 FOR P.C.B.
4. SEE 1720A-8001 FOR ASSY.
5. SWITCH POSITIONS BLANK 1 THROUGH BLANK 6 ARE NOT DECODED BY THE 1720A.

1720A-1010

Figure 6-11. Keyboard Schematic



1720A-1002

Figure 6-12. Mother Board Schematic

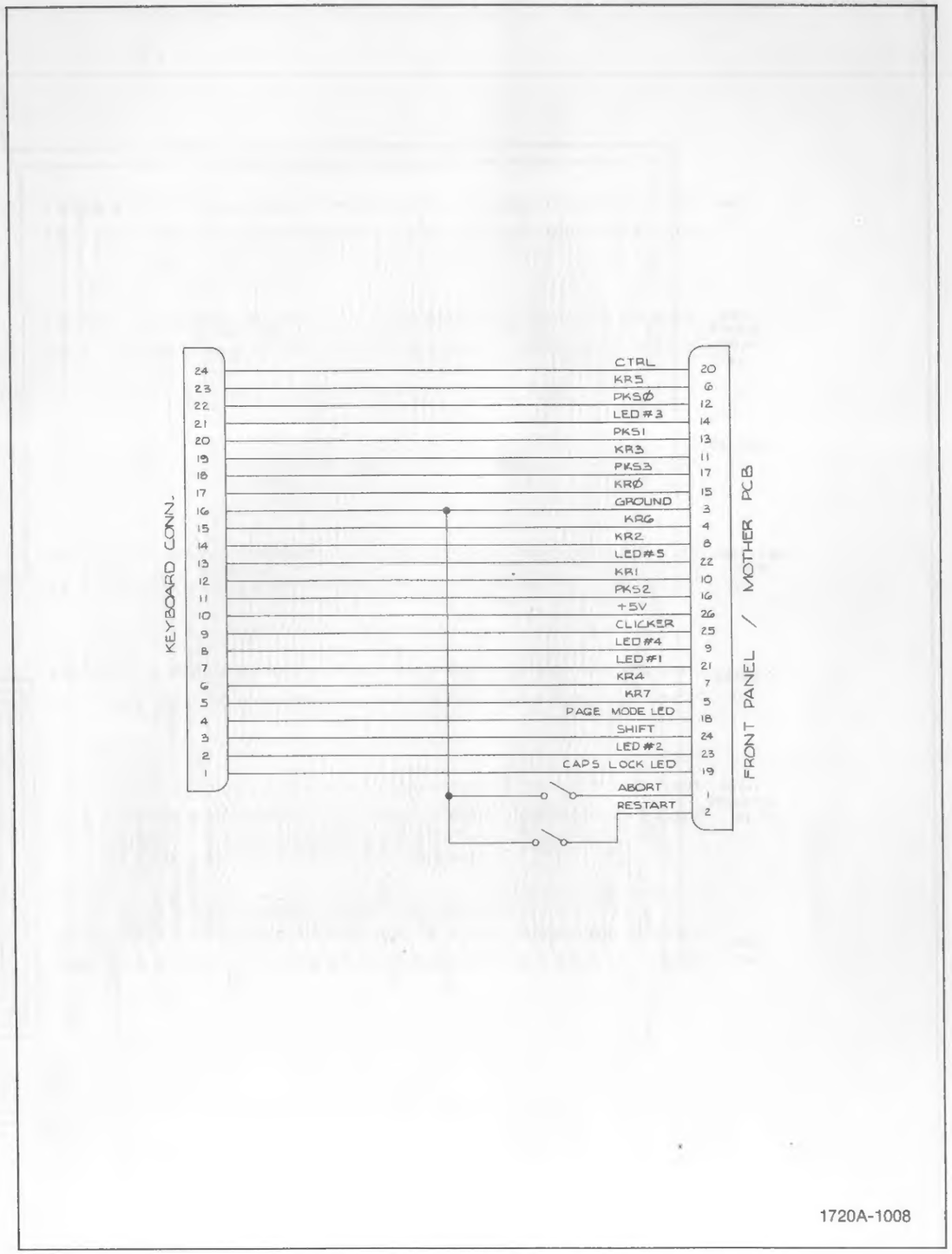


Figure 6-13. Front Panel Schematic